POWER PLANT ENGINEERING

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The Millers Ford Station

UNIQUE METHOD OF HANDLING CONDENSING WATER, FLOOD PROTECTION WELL AND SIMPLE ELECTRICAL LAYOUT FEATURES OF NEW DAYTON, O., POWER PLANT

DUE TO UNPRECEDENTED ACTIVITY on the part of those industries furnishing the government with supplies required for the maintenance of our armed forces and the prosecution of the war, the demand for power in many localities has become tremendous, and as a consequence not only have the capacities of existing plants been doubled, trebled and even, instances, quadrupled, but many new isolated and central stations have of necessity been erected. One of the most recent additions to the list of central stations primarily designed and constructed to aid in supplying the heavy demands placed upon the system to which it is connected, is that of the Dayton Power & Light Co., known as the Millers Ford Station, and located about three miles south of the business district of the city of Dayton, Ohio, at a point where the tracks of the Big Four Railroad cross the Miami River.

Even though at some distance from the center of distribution, the site selected is ideal for the location of a power plant. Coal is delivered by rail, but with the power house removed from within the limits of the local yards, the rail congestion frequently existing within the city of Dayton is avoided and deliveries, therefore, not interfered with; neither does the traffic due to cars consigned to the plant tend to aggravate conditions within the Dayton yards.

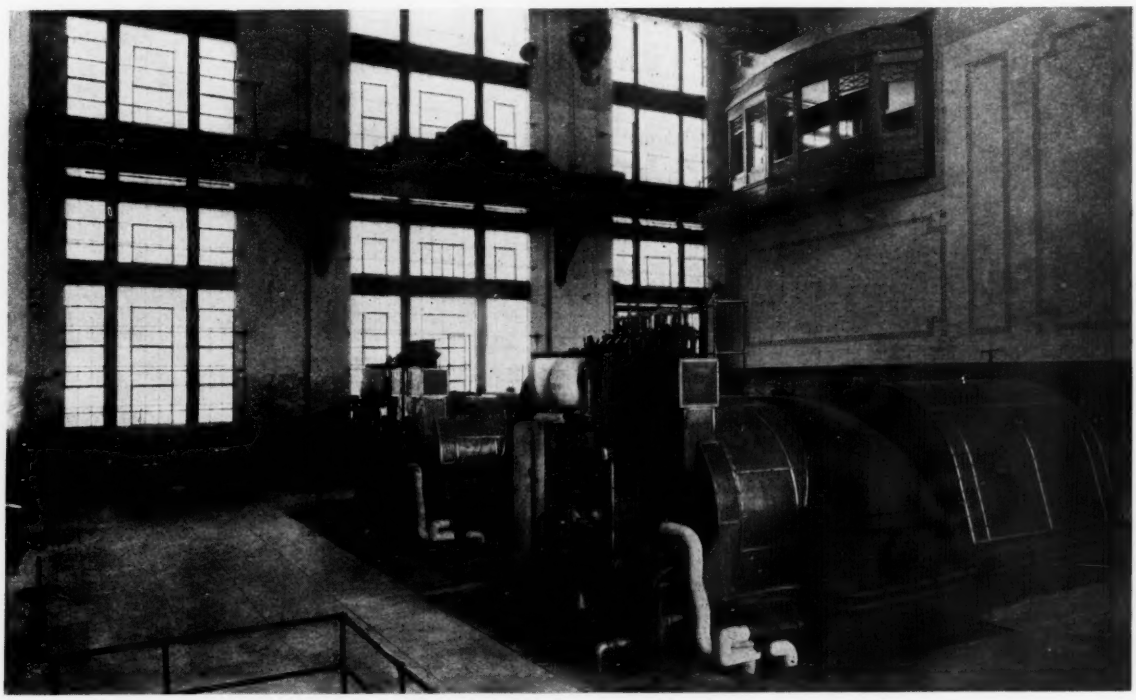


FIG. 1. GENERAL VIEW OF TURBINE ROOM

Another advantage is the abundant supply of water available for condensing purposes. This is brought into the plant by means of an underground concrete tunnel having sectional dimensions of approximately 8 by 12 ft., and so located and constructed as to divert a portion of the waters of the Miami River, thus acting not only as a source of supply to the condenser pumps, but

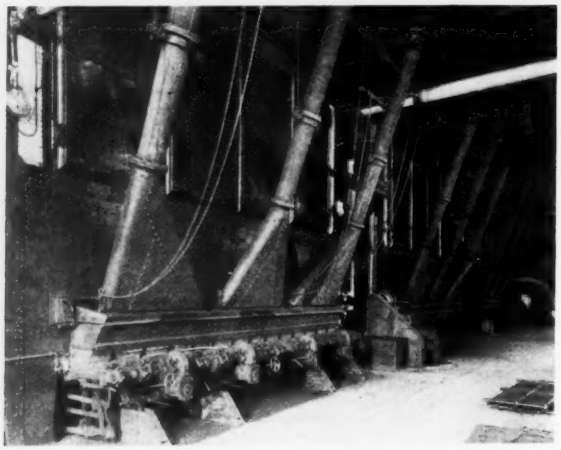


FIG. 2. BOILER ROOM, SHOWING FIRING AISLE

also as a means of discharge for the circulating water after it has passed through the condensing units.

As may be noted in the accompanying illustrations, the building is a steel structure with brick walls resting on a concrete sub-structure, and occupies a ground space of approximately 117 by 258 ft.: it has a height of about 100 ft. The boiler room with a width of 141 ft. 6½ in., is located at the south end of the building, while the turbine room and the switch house each with a width

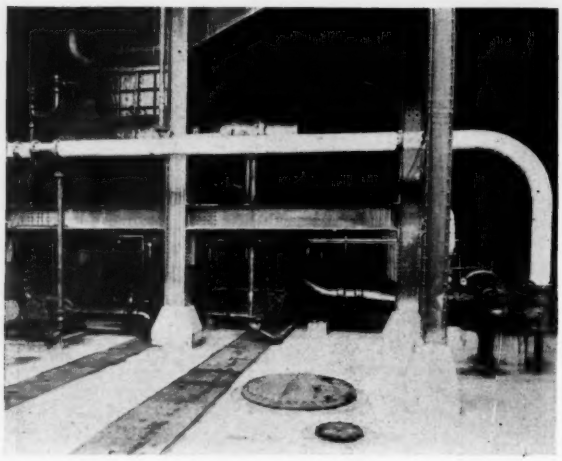


FIG. 3. CONDENSING EQUIPMENT

of 40 ft. 3½ in. and 76 ft. 8½ in., respectively, occupy the north end.

A somewhat unusual and interesting feature of the structural portion of this station is the form of sub-structure employed below the turbine room. During the wet seasons of the year, and especially the early spring, the waters of the Miami River frequently rise to such levels as to inundate many acres of land along the banks, and as a consequence, due to its location, the Millers Ford Station will undoubtedly be frequently threatened with floods. The designing engineers engaged on this work have, however, taken all precautions possible to avoid any trouble arising from this source, and have placed all of the equipment, except the condensers and their auxiliaries, below the high-water line. In the case of the condensers, however, ample protection has been provided in the form of a reinforced concrete well extending below the entire turbine room and so constructed as to insure against flooding, regardless of the condition of the river. Its side walls have a thickness of 4 ft., and except for the section through which

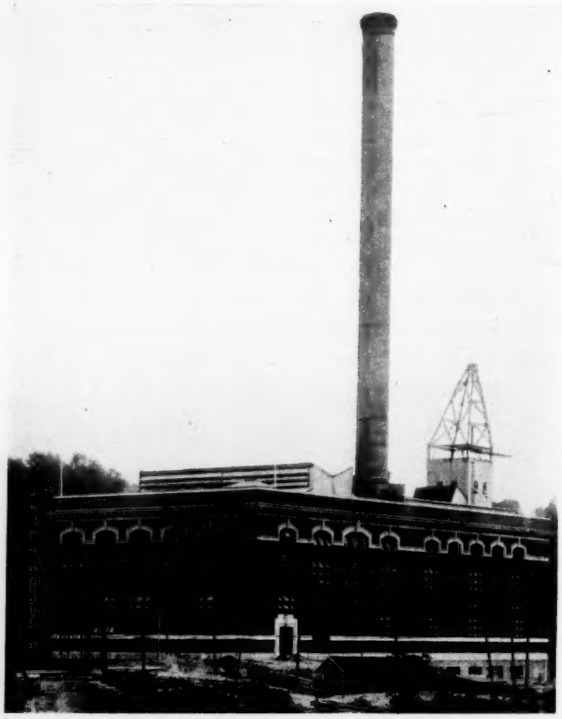


FIG. 4. EXTERIOR VIEW OF POWER HOUSE

the discharge and intake tunnels pass, at which point the total thickness of the concrete is about 24 ft., the bottom consists of an 8-ft. mat.

The brick lined stack shown in Fig. 4 is 16 ft. in diameter and 330 ft. in height; ultimately four of these stacks will be erected.

In the Boiler Room

As will be noted from the various illustrations shown, the present steam generating equipment consists of three cross-drum type Babcock & Wilcox water-tube boilers, each rated at 1500 hp. and equipped with a B. & W. superheater and a Taylor 14-retort stoker. Steam is generated at a pressure of 225 lb. gage and superheated 150 deg. F., thus providing a working temperature somewhat in excess of 545 deg. F.

Water used for boiler-feed purposes is taken from a deep well and is delivered to a 30,000-gal. storage tank by either one of two 300-gal. per minute Platt centrifu-

gal pumps, one driven by an electric motor and the other by a steam turbine. From this tank the water passes through a softener of the Power Plant Specialty Co.'s make, having a capacity of 3000 gal. per hour, and after being treated so as to produce one grain of hardness per gallon or less, as may be desired, it is delivered to a soft water tank from where it is taken as required. This soft water tank also has a capacity of 30,000 gal., and like the other is placed on the roof of the building.

The water treating apparatus consists of a precipitating and heating tank, a pressure filter to remove the lime precipitate, individual lime and soda ash tanks and a meter proportioning device.

Before being fed to the boilers, both returned condensate and makeup are caused to be preheated in either one of two Platt Iron Works No. 9 feed water heaters, after which the water is delivered to the system by any one or combination of two 500-gal. per minute, and one 1000-gal. per minute Platt turbine-driven centrifugal pumps, the number and size of units in operation depending upon load conditions.

Each of the 500-gal. units discharges through a 5-in. branch and the 1000-gal. pump through an 8-in. branch, all of which tie in with the distributing system, a loop of 8-in. line carried above the installed boilers, and that space reserved for future units. Two 3-in. feed branches serve each boiler, and in order to provide reliability of feed and economy of operation, S-C feed water regulators have been installed; the pressure on the feed line is under the control of Ford pressure control valves.

Coal and Ash Handling

With the rail facilities available, coal is delivered to the plant in cars brought over the main line of the Big Four Railroad and run on to a siding carried over a receiving pocket, having a storage capacity of about 400 tons. From there the coal is transferred to the 920-ton steel brick-lined bunkers in the boiler room, or if these have an ample supply on hand, it is removed to a storage yard by means of a McMyler-Interstate Crane Co.'s locomotive crane equipped with a 100-ft. radius boom, thus providing a wide range of operation.

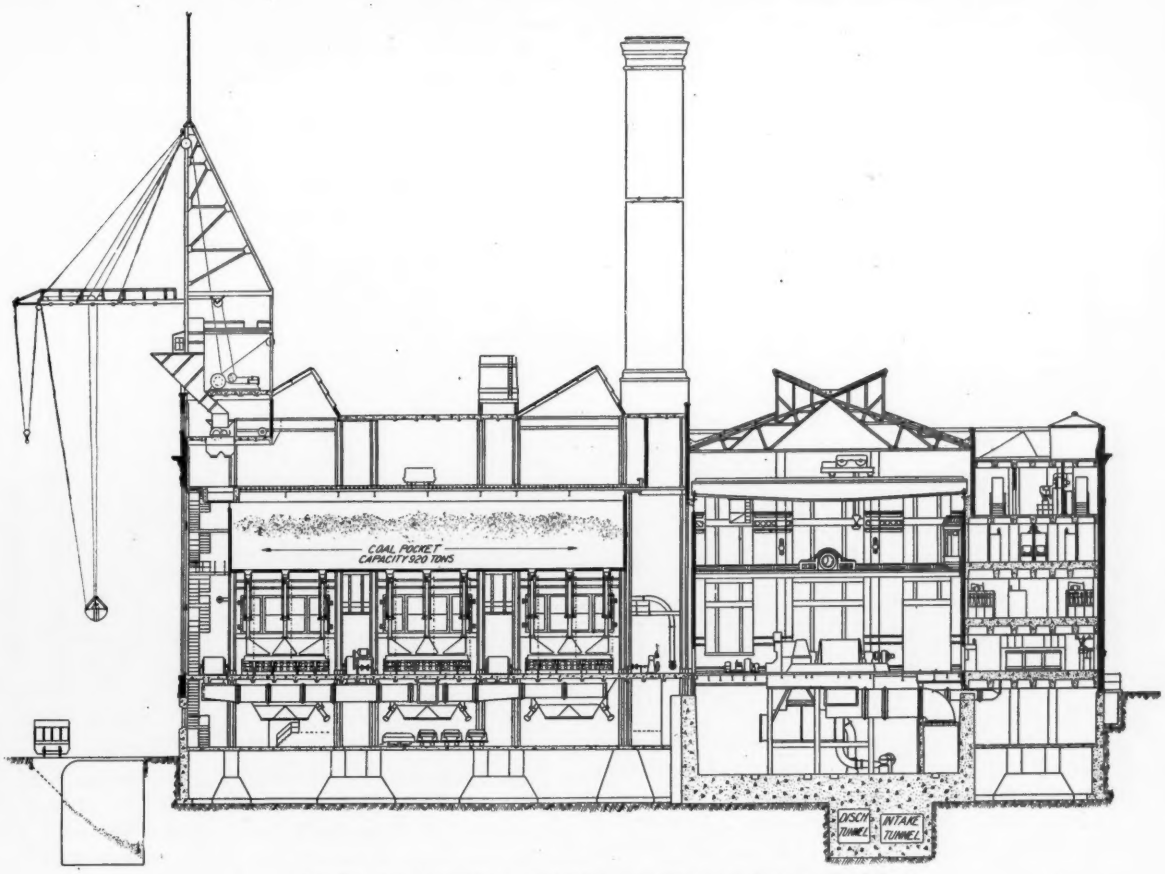


FIG. 5. LONGITUDINAL SECTION OF MILLERS FORD STATION

The coal raised to the bunkers is handled by a one-ton bucket used in conjunction with a steam-driven Meade-Morrison coal handling outfit, and as will be noted by reference to Fig. 5, is passed through a crusher which discharges it into a car placed on the platform of a scale where it is weighed before being delivered to the bunkers. From the bunkers the coal is fed to the stoker hoppers through chutes terminating as shown in Fig. 5, in fan-shaped spouts.

The boilers are equipped with Taylor 14-retort stokers and separate Sturtevant blowers operated at a speed of 715 r.p.m. through reduction gears by a 163-hp. turbine, the speed of which is under the control of the air pressure within the boxes.

A small Sturtevant upright engine and a 30-hp. electric motor are installed for the operation of the stoker shaft, and in order to provide the necessary degree of flexibility, this shaft is fitted with a Reeves variable speed drive.

At an elevation of 20 ft. below the boiler room operating floor is found the ash handling equipment. This consists of an electrically operated industrial railway, the cars of which, in passing below the ash receiving hoppers, are loaded through the medium of chutes provided for that purpose. At present, the ashes are used for filling the grounds surrounding the station.

High-Pressure Steam Piping

With the scheme of arrangement of equipment employed, it was possible to use a comparatively simple high-pressure steam piping layout. Essentially this consists of a loop system with two primary branches serving the main units, but so valved as to allow the cutting out of practically any section without material interference with the operation of the plant.

The main header is, as shown in Fig. 6, arranged in the form of a loop and consists of 15 and 14 in. sections, except that portion along the farther end of the boiler room, which as may be seen is made up of 12 in. lines and connections.

Expansion and contraction are cared for by bends inserted in the tie connection between the two main headers.

Each of the boilers supplies steam to the header through two 8-in. leads, each fitted with an 8-in. automatic stop and check valve near the boiler outlet, and a stop valve of like size located adjacent to the tee in the header.

The distributing header consists essentially of a bypass arrangement tied in with the main header at the turbine room end of the loop and is made up in the main of 15-in. sections and fittings. Fifteen-inch bends are used for tying-in purposes and serve the distributing header through valves of like size which through the medium of 15 by 15 by 6-in. tees also control the flow of steam to the auxiliary apparatus.

Twelve-inch branches connect with the main units.

The main distributing header also is well valved to insure flexibility of operation and continuity of service, and in order to prevent any unnecessary strain being set up due to expansion and contraction of the system is fitted with a loop having a total length of approximately 21 ft. 7½ in. and an offset of about 8½ ft.

Drip pockets and strainers are inserted in each of the turbine supply leads.

All high-pressure steam lines are equipped with Chapman cast steel gate valves while the boiler feed lines are fitted with extra heavy iron body gate valves, also of Chapman make.

Measurement of water flow is by means of Yarway V-notch meters.

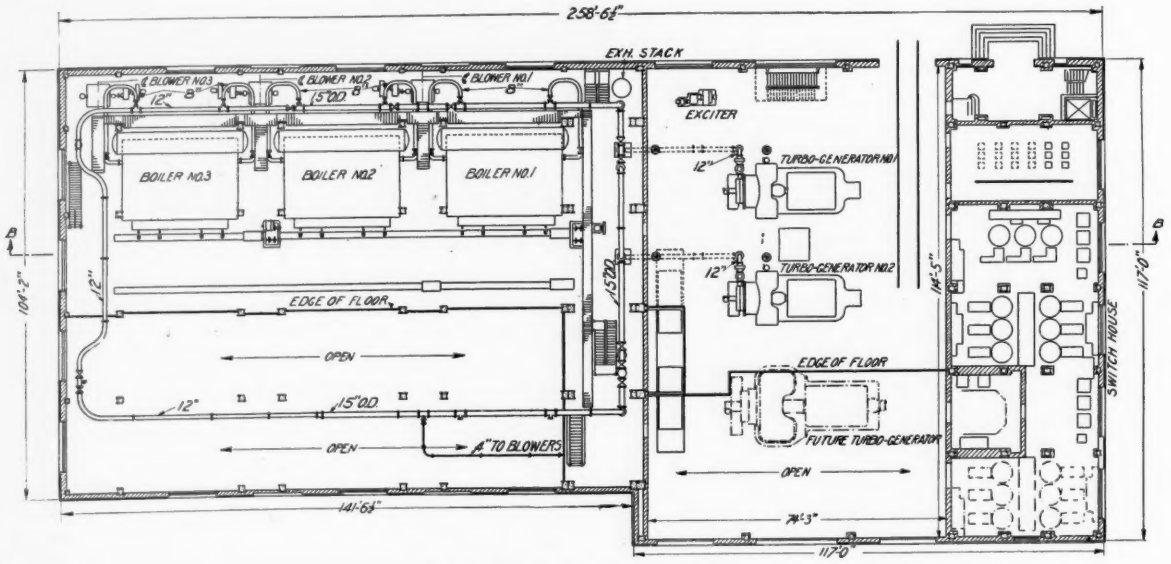


FIG. 6. PLAN OF POWER PLANT

Main Generating Units

Although the initial generating equipment consists of but two General Electric turbine-driven units, each rated at 12,500 kv.a., 6600-v., three-phase, 60 cycles, provision has been made in the design and construction of the plant to increase the ultimate capacity of the station to 150,000 hp. Current for the excitation of the fields of the main generators may be obtained from any of the three exciter units installed for that purpose. Two of these are direct connected to the machines they ordinarily serve, while the other, primarily intended for emergency service, consists of a 5200-r.p.m. impulse turbine of Westinghouse make geared to a 100-kw., 250-v. generator running at a speed of 900 r.p.m. The use of the reduction gear allows each machine to operate at its most economical speed, which in the case of the turbine is maintained within a variation of three per cent from full load to no load. Lubrication is by forced oil supply from a small rotary pump; water cooling coils are provided in the oil reservoir. Water sealed glands are

used instead of the stuffing box commonly employed, thus insuring a high degree of vacuum and the elimination of packing replacement expense.

Each of the direct connected exciters is rated at 85 kw. and is of sufficient capacity to care for both main generating units should for some reason the other two exciters become inoperative.

Condensing Equipment

Surface condensers of Westinghouse make are used in conjunction with the main units. Each contains 3043 tubes and has an effective condensing surface of 15,000 sq ft., which when condensing 164,000 lb. of water at a temperature of 70 deg. F. is capable of maintaining a vacuum of 28 in.

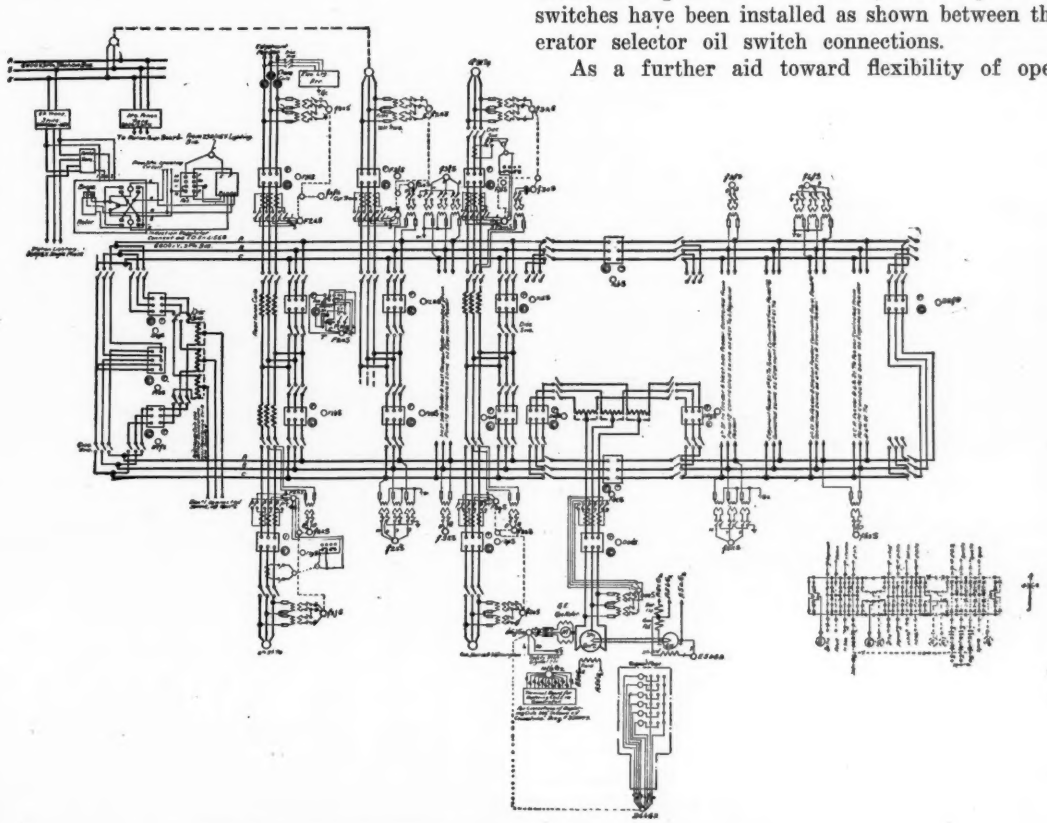


FIG. 7. DIAGRAM OF CONNECTIONS OF ELECTRICAL EQUIPMENT

Cooling water is circulated through the condensers by Platt Iron Works centrifugal pumps having 36-in. suction and 28-in. discharge connections, and operated at a speed of 700 r.p.m. under a dual drive, one end of each unit being connected through a reduction gear to a 3500-r.p.m. steam turbine, and the other end directly to an electric motor, the speed of which is identical to that of the pump.

Air and condensate pumps are of the combined type, driven by a direct-connected turbine.

In addition to the regular condensing equipment, there have, also, been installed for emergency service an extra condensate pump having a capacity of 800 gal. per minute and operating at a speed of 2000 r.p.m. and an air pump for use in connection with either condenser.

Electrical Control and Switching Equipment

Shown in Fig. 7 is a diagram of the station electrical system. The machine leads, each of which consists of two 1,000,000-circular mil stranded conductors carried in parallel, a scheme employed to reduce the effective resistance due to skin effect, connect through the medium of a 2000-amp. generator oil switch with a combined generator and bus tie reactance, having a reactance of 11 per cent from end to end, and 4 per cent from neutral to either end. From this point, the current may flow through either one or two branches, each connected to one end of the reactance and carrying in addition to two disconnect switches a generator selector oil switch, also of 2000 amp. capacity. For the sectionalizing of the main buses, 2000-amp. bus tie oil switches have been installed as shown between the generator selector oil switch connections.

As a further aid toward flexibility of operation and continuity of service, each of the feeder or tie line leads, in which is inserted a feeder reactance, a 600-amp. feeder oil switch and two disconnect switches may be supplied with current through either one or two 1200-amp. feeder group selector oil switches connected to the main bus bars by means of the necessary disconnect switches.

Arrangement of Switching Apparatus

On the first floor of the switch house, the elevation of which is the same as that of the generator and exciter room, are installed the main and auxiliary direct-current switchboards for exciters, etc., the switchboard for local service in and about the power house, compartments for the transformers for local service and those

for the outgoing high-tension lines and the main oil circuit breaker structure. The house service is cared for by two banks of transformers. One of these banks, that used for power supply, consists of three 300-kv.a. units connected in delta, while the other bank installed primarily for lighting service consists of but a single unit rated at 200 kv.a.

Current from these transformers is delivered to power and lighting distribution boards, the former built up of three panels and the latter of two panels and equipped with Metropolitan type switches in which the protective fuse is caused to serve as the switch blade.

Due to the fact that this station will primarily serve high-tension lines, it will be necessary to maintain the voltage at a value most suitable to the requirements of

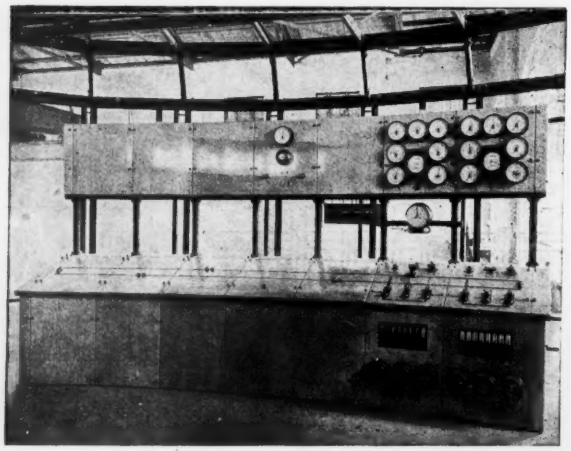


FIG. 8. MAIN BENCH BOARD

the service. Undoubtedly this would frequently tend to interfere with the local service, and in order to prevent any unnecessary voltage disturbances on the lighting lines, an induction regulator has been provided.

On the second floor are found the oil circuit breakers for the bus tie lines as well as the structures for the 6600-v. buses and the generator and feeder bus switch structure; the third floor houses, the remaining bus structures, the reactances, the control desk and the various switchboards.

As shown in Fig. 8, the control desk which has been so placed as to give the operator a full and unobstructed view of the turbine room consists of seven sections of bench type boards constructed of polished blue Vermont marble and built up into circular form. At the present time, sections four, six and seven only are being utilized, section four to carry a 60-cycle frequency meter and a syncronoscope, and sections six and seven for the control of the two main generating units; the latter are equipped with the necessary regulating and switching devices and meters, and also a signaling system for communicating with the operating floor.

The feeder board is shown in Fig. 11 and in conformity with the other switchboards is also of the blue Vermont marble. It provides for 11 outgoing feeders and for each feeder there is an indicating wattmeter, three ammeters, and three definite minimum inverse time limit overload relays interconnected with the oil switches.

An eight-panel curved front board provides for the control of the generator fields. The first four panels have been left blank for future machines, but the fifth and sixth, and the seventh panels, each carry the necessary control and meter equipment for a 170-kw. motor driven exciter to be installed in the future, and the 100-kw. turbine driven exciter, respectively. The eighth panel carries a Westinghouse generator voltage regulator with equipment to compensate for line drop so as to maintain constant the voltage on the lines serving one of the Dayton sub-stations.

All of the rheostats and circuit breakers are remotely controlled.

Figure 10 pictures the three-panel meter and battery board. On the first panel is mounted the 230 v., 120 amp.-hr. battery control equipment, and on the second panel a frequency meter and an alternating current voltmeter, both of the curve drawing type; the third panel carries the ground detector indicating lamps, and six sets of jacks for exploring coils connected with the main generator windings.

Switching Equipment

For the generators there is furnished an equipment of Westinghouse type 0-2 non-automatic oil circuit breakers rated at 75,000 arc amperes per phase at 6600-v. Warning of overload on the individual machines is given by overload relays which light a signal lamp located on the generator panel. The bus sectionalizing switches

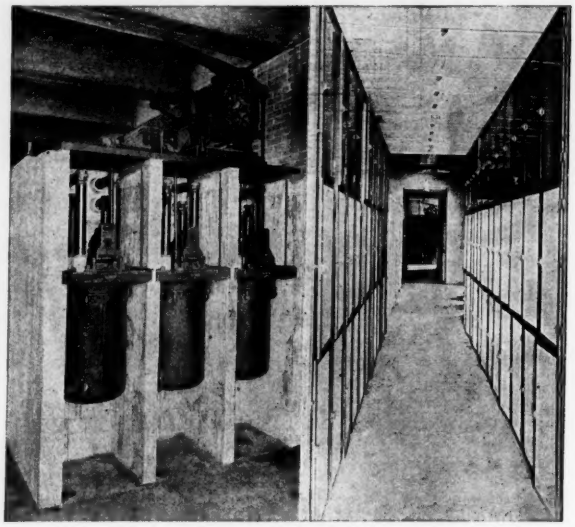


FIG. 9. BUS STRUCTURE AND TYPICAL OIL SWITCH

are also Westinghouse oil circuit breakers and are likewise rated at 75,000 arc amperes per phase at 6600 v., with a continuous rating of 2000 amp.

For the feeder groups there are provided Westinghouse type B-8 non-automatic circuit breakers rated at 12,000 arc amperes per phase at 6600 v., and for the individual feeders type E-6 circuit breakers, each rated at 30,000 arc amperes per phase at 6600 v. and equipped with an automatic overload trip.

Storage Battery Equipment

Current for the operation of the electrically operated oil switches and the emergency lighting circuits is

supplied by a storage battery located in a separate room on the same floor as is the main control board. This battery, which is capable of delivering current at approximately 230 v., has a rating of 120 amp.-hr.

Outgoing Circuits

Six of the transmission circuits, each 6600 v., three-phase, are carried across the Miami River, and are arranged in a vertical plane. The supporting towers, built up of massive works of structural steel, are so placed as to give the lines a span of 850 ft. with a maximum sag of about 18 ft.

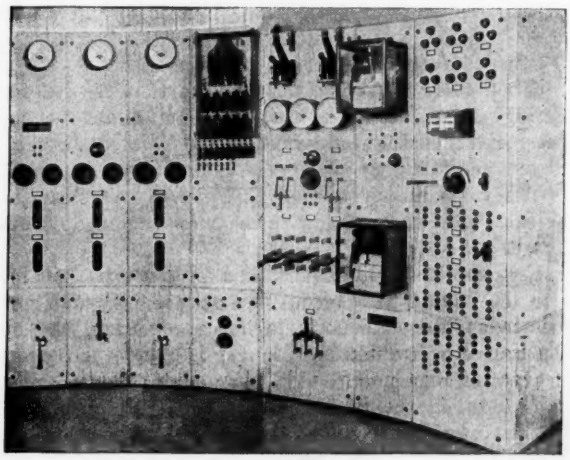


FIG. 10. EXCITER, REGULATOR, METER AND GROUND DETECTOR PANELS

Westinghouse choke coils and lightning arresters of the three phase electrolytic outdoor type have been placed on the tower, on the station side of the river.

New Essington Works Exceed Schedule by 50 Per Cent

THE ship-yards of our country, which at the present time are working at utmost speed in fulfilling the government's tremendous ship-building program, are in a large part entirely dependent upon the manufacturers, who produce the necessary machinery that goes into these ships. These manufacturing establishments are more than doing what is demanded of them, as establishments for winning the war, and are filling the government's orders in a fine manner. This war-time spirit has more than been demonstrated by the Essington Works of the Westinghouse Electric and Manufacturing Co. in South Philadelphia. Their record for the month of August was not only larger than the shipment for any similar time since the works commenced its operations, but it was actually 50 per cent in excess of what their schedule called for.

These works have concentrated their efforts upon the construction of ship propulsion machinery, such as steam turbines, mechanical reduction gears, condensers, pumps and other auxiliary steam apparatus, all of which comprises the Westinghouse Marine Power System, 100 per cent of the material being turned out by their government contracts; 90 per cent of this balance to the United States Navy.

Up to Sept. 1, the company has shipped to the Submarine Boat Corporation of Newark, N. J., a complete equipment of ship propelling apparatus for eight vessels, and 20 complete sets of line shafting. An entire steam power equipment for two vessels, together with six complete sets of line shafting had been furnished to the Merchant Shipbuilding Co., of Harrisman, Pa. To the Newburgh Shipbuilding Co., of Newburgh, N. J., have been furnished two complete sets of line shafts and the United States Navy Yard at Norfolk, Va., was supplied with two complete sets of turbines and reduction gears for a revenue cutter as well as two sets of reduction gears for destroyers.

A keen spirit of friendly rivalry exists among the employers of the various departments of the Essington Works, this serves the plant by speeding up the production of the different departments. Everybody seems to realize that in carrying out the government's ship-building program they are doing work of the most vital importance.

While the men in the shipyards build the hulls and the framework, they are constructing the skeleton, so

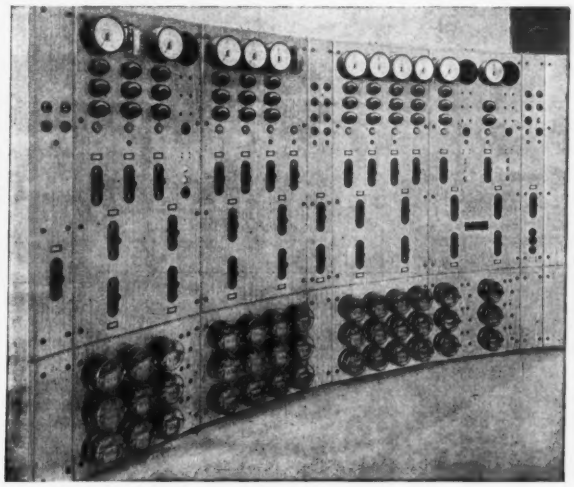


FIG. 11. FEEDER PANELS

to speak; but it is the men at the manufacturing works throughout the country who furnish the machinery which makes the launching of the ship possible as well as the power which makes the ships move over the Atlantic to Europe, and thus helps to win the war.

In a paper before the American Supply & Machinery Mfrs. Assn., C. F. Beezley, Jr., showed the great number of catalog sizes at present in use, and advocated as a matter of saving paper and labor the standardization on three sizes: 6 by 9-in., 7¾ by 10⅝-in. and 8½ by 11-in. He advocates 6 by 9 as the standard and minimum size, which folds and trims without waste from a standard 25 by 38-in. sheet.

We have spent over $500,000,000 to clothe our soldiers.

Every subscriber to the Liberty Loan has had a part in this care of the Americans who are fighting in France.

Using Exhaust Steam

VALUE OF EXHAUST STEAM; LIMITATIONS OF ITS USE; EFFECTS OF ENGINE EFFICIENCY; HEAT AVAILABLE WITH VARIOUS TYPES OF ENGINES. BY S. E. BALCOME

AN engine taking steam at any pressure and exhausting into a lower pressure does not use or take from the steam a very high per cent of its heat, even if running condensing, the efficiency of the best of them not being over 20 per cent, thus leaving 80 per cent of the heat in the steam which is exhausted into the condenser or atmosphere; if into a condenser, the engine efficiency is of course higher than it would be if exhausted into atmospheric pressure, as the back pressure is less.

The efficiency of the engine, however, is not the whole thing in all cases; there are conditions in factories and institutions and other places where steam engines are used where it is better to exhaust the steam against a pressure of one or two pounds above atmospheric and use the steam for heating water or buildings, or drying, thus using all of the heat in the steam instead of condensing the steam and throwing away the cooling water.

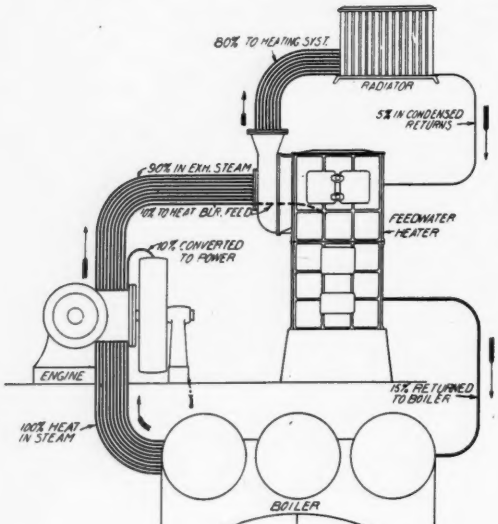


FIG. 1. HEAT CYCLE IN AN EXHAUST STEAM SYSTEM

If all of the exhaust steam can be used, as for instance where the power use is small and the buildings to be heated are large or there are a great many of them, there will not be enough exhaust steam to heat the buildings in winter, so that it would be folly to condense the steam from the engine in a condenser and then use live steam to heat the buildings. For instance, an engine runs a generator in an institution. This engine has an efficiency of 15 per cent running noncondensing and 18 per cent running condensing. Now, if in winter we should run the engine condensing, we would use 18 per cent of the heat in the steam and throw away $100 - 18 = 82$ per cent in the cooling water; if we should run the engine noncondensing and use all of the exhaust in the heating system, we should use 100 per cent of the heat in the steam and throw away none, except of course the heat that radiates from the engine, and even that might be needed to warm the engine room. We should require a certain amount of heat in the buildings, and all of the heat in the exhaust steam would need to be replaced by live steam if we did not use the exhaust.

When there is more exhaust steam than needed for heating all of the time, the foregoing might not be true. Every case would need to be studied out and treated accordingly.

The value of dry exhaust is equal to live steam of the same pressure. Going through an engine does not hurt it.

Separators should be installed in the exhaust pipe near the engine to take out the cylinder oil and condensate as the condensate is not needed and the oil is a source of trouble and danger if the returns from the heating system are used over again in the boiler. In fact, oil in the pipes and heaters is undesirable as it coats the pipes inside and interferes with the proper working of the return valves on the coils, radiators and heaters.

If a large portion of the exhaust be used for heating or drying purposes, the power generated by the engines becomes a nearly costless by-product, or from another point of view, the heating is practically free of charge. Nevertheless in many plants exhaust steam is still wasted to atmosphere or is sent to a condenser, or electric current is purchased for power, while at the same time coal is being burned to produce live steam for heating purposes. Such wasteful practice is most often due to lack of familiarity with the best methods and means of utilizing exhaust steam.

The use of exhaust steam for heating purposes not only offers the possibility of cutting the fuel bill nearly in half, but by conserving the pure condensed returns from the heating system and utilizing them as boiler feed it is in many cases possible to reduce the water bill by 80 per cent and at the same time to cut off a large part of the expense of removing periodically from the boilers the scale that is deposited from most natural waters.

The most profitable use to be made of exhaust steam is in heating the boiler feed water, since not only is heat conserved and fuel saved thereby, but the boilers are protected from temperature strains, the water is purified by the driving off of gases and the consequent precipitation of carbonates, and the capacity of the boilers is increased in the ratio borne by the heat imparted to the feed water from exhaust steam to the total amount of heat required to convert the cold water into steam, or from 10 to 16 per cent. Any surplus of exhaust steam remaining after heating the feed water becomes available for heating, drying, etc., by utilizing

it in any of the well known vacuum or back-pressure systems and with direct or indirect radiation as conditions may dictate.

Adaptability

Steam cannot be made to heat anything to a point above its own temperature, so that where it is best to keep the pressure of the exhaust down low, 1 or 2 lb. above atmosphere as in plants where the power requirements overbalance the heating requirements, and there is always more exhaust steam than is needed, the use of it is limited to heating buildings, heating water or solutions, drying or to any class of heating which does not require a temperature above 212 deg. F. However, there is a great deal that can be done by steam at that temperature which at the present time is done by steam at a higher pressure and temperature. For instance, the writer knows of cases where quick drying is required and in order to do this without using too much space and piping, live steam at high pressure is used. Exhaust steam at low pressure would do it just as well if more heating surface were added because the temperature in the dryer need not be over 150 deg. F. and that is a great deal below 212.

These cases are true up to the present time because not much attention has been paid to the conservation of exhaust steam, it being considered a by-product or waste product, something which was to be thrown away and not much thought given to it. But now it is different. It has become necessary to save coal, and when we come to think of it there are many ways in which exhaust steam can be used.

It may be possible in many cases to balance up the power load and heating requirements so that at least in winter no exhaust steam shall be seen issuing from the exhaust pipe. This may be done by systems of district heating, furnishing hot water for apartment houses and other places.

For sterilizing, cooking, coffee urns, laundry mangles, and machines which need high temperature and pressure steam, live steam is required, although where the power requirements are small and the call for steam large, a high back pressure may be carried in the exhaust system and as long as it was all used, the high back pressure does not affect the efficiency of the whole plant in the least. The engine efficiency, of course, would be lower; but that does not make any difference as long as the steam is all used; the efficiency of the steam would be nearly 100 per cent. Of course, in many places the exhaust steam is all used part of the time and at other times there is more than enough so that some of it escapes at the exhaust head, and in these places a high back pressure would be undesirable.

Exhaust steam can be used in cooking vegetables as a low pressure is sufficient for that purpose, but it must be perfectly clean. Steam from turbines which have no cylinder oil may be used for that purpose. Where water is to be heated, it must pass through a heater designed large enough to heat the water as fast as needed or it must be heated and stored in a tank by piping a heater so that the water will circulate from the tank to the heater and back to the tank, or it may be heated by laying a coil of pipe in the bottom of the tank and connecting to the exhaust steam system. The condensate returns must be taken from the end of the coil and must be piped out through the bottom or near the bottom of the tank so that the water would drain from the coil by gravity. Exhaust steam cannot be blown into water where the height of the water in the tank is higher than the pressure of the steam can overcome, 1 lb. pressure being equal to 2.3 ft. in height.

Effect of Engine

Back pressure naturally lowers the efficiency of any engine, the higher the back pressure the lower the efficiency, so that when the exhaust steam is not all used

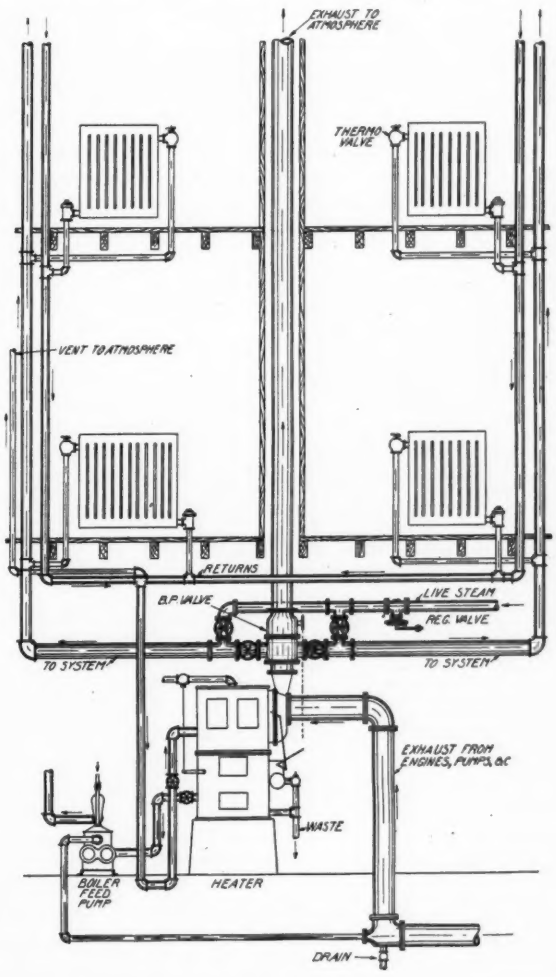


FIG. 2. KINEALY SYSTEM OF EXHAUST STEAM HEATING

the back pressure should be kept as low as possible, generally speaking. This may be kept down in most cases by using vacuum returns and connecting them to all coils and radiators. This will ensure good circulation with low back pressure on the engine or engines.

For example, a perfect engine with an initial pressure of 130 lb. absolute (115 lb. gage) will consume 16 lb. of steam per horsepower hour when exhausting to the atmosphere. With 5 lb. back pressure, the consumption will be 18 lb. of steam or an increase of 12½ per cent. With an engine using 30 lb. per horsepower hour and working at the same initial pressure, we may

expect a steam consumption of 30×1.125, or 33.7 lb. per horsepower hour if we change from atmospheric exhaust to 5 lb. back pressure. These calculations are based on the performance of a perfect engine and the steam consumption of actual engines is affected in about the same proportion.

The loss in efficiency is, however, not the only objection to high back pressure, as the engine might be heavily loaded and therefore not able to carry the power needed unless the boiler pressure were raised enough to overcome the loss due to the high back pressure.

Steam from Receivers of Compound Engines and Bleeder Turbines

Steam at a moderately high pressure can be obtained from receivers of compound engines and bleeder turbines, the limit of receiver pressure being in general 50 lb.

In using steam from receivers and bleeder turbines we should be careful to study conditions. If there should be only exhaust steam enough for use in heating

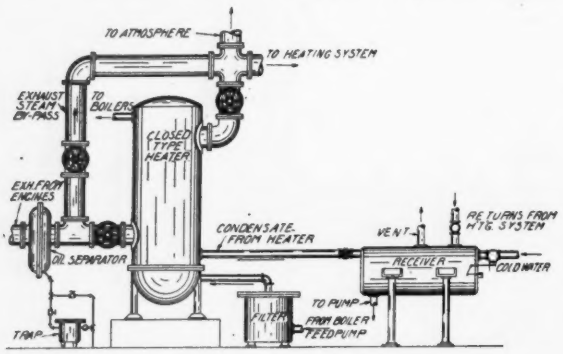


FIG. 3. APPARATUS REQUIRED WHEN A CLOSED HEATER IS INSTALLED IN CONNECTION WITH AN EXHAUST STEAM HEATING SYSTEM

where it could be used at low pressure, there would not be any reason for using a bleeder turbine, or taking steam from the receiver of a compound engine. If more steam was needed than the exhaust would supply, it should be taken from the boiler direct; but in case the amount of steam exhausted from the engine was more than enough to supply heating demands, a bleeder turbine would be an economical machine when running condensing, because enough steam could be extracted from one of the middle stages to supply all the heat needed and let the rest go through the turbine to the condenser thus doing work.

A compound engine is similar in this respect to a bleeder turbine, the receiver taking the place of the part of the turbine where the steam is extracted and the low pressure turbine corresponding to the low pressure cylinder of the compound engine. The action of each is alike with the exception that in a bleeder turbine, an automatic valve is installed between the high and low pressure turbine, designed to shut off the steam from the low pressure part corresponding with the amount of steam taken out of the extraction chamber, and throwing more work on the high pressure turbine. At this point, the writer would like to add a little description of the principles and action of bleeder turbines which is copied from instructions from the General Electric Co.

"Almost all bleeder turbines are designed to extract steam at 10 lb. pressure, which is high enough for most cases.

"The extraction pressure is controlled by varying the steam passageway area between the extracting stage and the next stage toward the condenser. With constant extraction, an increase of load will call for increased passageway area and vice versa. With constant load on the turbine, an increased extraction will call for decreased nozzle area at the point stated and vice versa, so that the pressure in the extraction stage is kept constant by the automatic extraction valve but it is also arranged that the extraction valve will not completely shut off the steam from the low stage of the turbine as there must be some steam flowing through in order that the rapidly running blades shall not heat up. The amount of steam which can be taken from a bleeder type of turbine can be determined definitely when load to be carried is known."

Relative to Heating Buildings

Line drawings of installation of heating system mains showing proper method of connecting pipes and return pipes in taking exhaust steam from the engine to the heating system are shown in the accompanying illustrations. It will be noted that a reducing valve is installed in the live steam connection and this reducing valve should be one which is regulated from the main heating pipe by a small pipe called a feeler. There are many types of these valves which will regulate the pressure in the heating pipe within 1 or 1½ lb., shutting completely off when there is enough exhaust steam to hold the pressure without addition of live steam. Care should be taken in adjusting these and the back pressure valve so that the reducing valves will close at least 1 lb. lower than the pressure which will open the back pressure valve, because where a reducing valve is installed at quite a distance from the engine there is a chance for a loss in pressure between the two valves due to flow of steam and the back pressure valve might be discharging steam into the atmosphere and at the same time the reducing valve would be feeding live steam into the system.

Following is an example showing method of calculating amount of square feet of radiating surface which a 100-hp. engine will supply together with table showing amount of steam used by different types of engines and steam pumps from which, if the actual horsepower used is known, the amount of radiation which the exhaust will supply can be found.

A simple engine requires 35 lb. of steam per horsepower per hour on an average. This steam will contain, say, 980 heat units as it is exhausted, and the engine will therefore deliver about 34,300 heat units per horsepower per hour in its exhaust. About 3,430,000 heat units are thus available from a 100-horsepower engine per hour. If this were all used in a heating system and the returns came back at 150 deg. F. there would be available roughly 3,000,000 B.t.u. Allowing a radiation of 250 B.t.u. per sq. ft. from the ordinary radiator, the exhaust from a 100-hp. engine would there-

fore supply roughly 12,000 sq. ft. of radiation, provided no steam were used for heating the feed water.

	Non-condensing	Condensing
Simple high-speed engine	30 to 34	22 to 26
Compound high-speed engine	24 to 28	18 to 22
Simple elevator pumps	120	
Compound elevator pumps	65	
Triple elevator pumps	40	

About 80 per cent of the steam supplied to an engine is discharged in the form of steam at a low pressure. The latent heat in a pound of steam at atmospheric pressure is 970 B. t. u.

In the preparation of this article, some data and drawings were secured from the Harrison Safety Boiler Works.

Economical Engine Operation

PROGRAM FOR STARTING AND STOPPING ENGINES IN AN ASSUMED INDUSTRIAL PLANT. BY MARTIN O'CONNOR

THE QUESTION of economy in the power plant being of such importance at the present time, it will be the purpose of this article to show the importance of operating engines at the capacity at which they show the best economy.

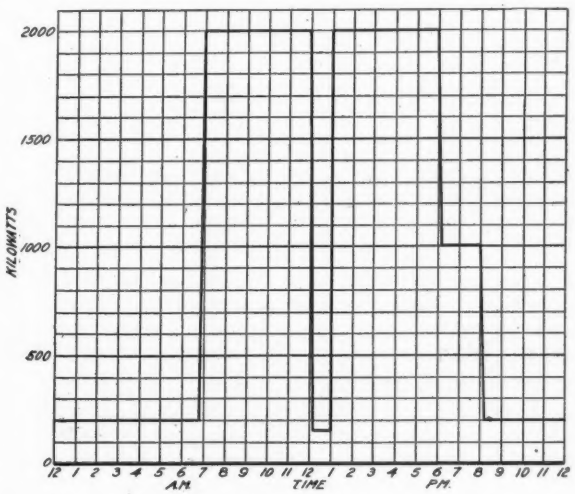
We will assume the case of an industrial plant having three units of 250, 750 and 1500-kw. capacity. The load in a plant of this kind at present is usually divided into three periods during the 24 hr.; viz., the regular day load, the overtime load for 2 or 3 hr. during the evening and the night load.

The engineer should arrange to have in operation during each of these periods the unit or units that will carry the load at best economy. As a help to the engineer in knowing in advance what the load is to be, one large plant has adopted the plan of having each department head report to the superintendent's office when power is needed in his department outside of the regular working hours. This information is given to the engineer and enables him to have the proper equipment in operation and avoid any interruptions to the service. The steam consumption per indicated horsepower hour for each of the three units mentioned will be nearly the same and will vary but little from ¾ to 1¼ load; the friction and windage losses, however, remain the same for all loads and amount to about 10 per cent of the engine's rating. The condensing outfit (where used) requires practically the same power at all loads.

It will be seen from this that it will be better economy to keep machines rather overloaded than underloaded. The load on the plant under consideration is assumed to vary as shown in the chart. The 2000-kw. day load can be handled by the 1500 and 250-kw. machines at a 15 per cent overload; the 1500-kw. unit is shut down during the noon hour. This should show a noticeable saving over operating the 1500 and 750-kw. and changing to the 250-kw. during the noon hour, which plan some might adopt.

The 750-kw. could handle the overtime load for 2 or 2½ hr. during the evening without overheating the generator. The 250-kw. is again started to take the load to 7 a. m. It might be said that the 750-kw. is in operation but a short time each day as compared with the other machines, but this machine can probably be used to advantage during slack times, when repairs are being made to other machines and for other emergencies that may occur. In cases where the noon period is but ½ hr., nothing is usually gained by changing to a smaller unit, as any steam saved by the small unit is lost in the warming up and changing over process. But if an hour is allowed for noon, changing to a proper size unit is advisable.

In case compound engines have to be operated non-condensing, efforts should be made to carry a sufficient load to prevent the expansion curve in the low pressure cylinder from falling below the atmospheric line, as when this occurs the low pressure cylinder becomes a drag and the engine is very uneconomical. Finally, it should be remembered that proper arrangements should be made in the boiler room to handle the different loads or much good work otherwise will be for naught.



ASSUMED DAILY LOAD CURVE

Smokeless Combustion with Chain Grates*

BY T. A. MARSH†

THE CHAIN grate has been in the field since 1871 in this country, and furnace designs giving smokeless installations under the many varied conditions are quite definitely established among combustion engineers. Chain grate manufacturers and their engineers have had no small part in the development work which has led to this satisfactory situation, having first bent their efforts in this direction some 15 yr. ago. This was prior to the existence of a large number of our present types of stokers, as well as to the existence of but very few organized smoke departments.

In the early days, the bulk of chain grate installations were sadly lacking in proper furnace proportion and design; but in spite of the fact that these initial

* Abstract of paper read at the annual convention of the Smoke Prevention Association.

† Chief engineer, Green Engineering Co.

stokers were set directly under the boilers, observation established two significant facts:

(1) Even in the absence of adequate furnaces, chain grates were good performers from a smokeless standpoint.

(2) Boiler tests indicated high hydro-carbon losses, due to insufficient space for their combustion.

The campaign for setting boilers higher to provide ample furnace space for more complete combustion was most difficult. Engineers, architects and owners rebelled at the extra cost. It was not until city smoke departments, backed by city ordinances began to exert their influence that our problem was simplified. The Chicago Department is very specific regarding boiler height and furnace proportions.

From year to year furnace volume has increased. Ten years ago furnaces having 2 cu. ft. for each square foot of grate area were quite common. Today we have furnaces providing as high as 20 cu. ft. per square foot of grate surface, while those having 6 to 8 cu. ft. are the general rule. It is becoming quite a necessity to discuss furnaces in terms of cubic feet per square foot of grate surface.

Let us consider how these large furnaces affect their settings. Ten years ago vertically baffled boilers of the B. & W. type were often set as low as 7 ft. from the floor line to the bottom of the header. Now 12 ft. is considered none too much, although this type of boiler with chain grates will perform within the Chicago ordinance at 200 per cent rating when set only 9 ft. under header. So this large furnace is not provided entirely to secure smokelessness.

Horizontally baffled boilers set 7 ft. under the header will give similar results. Return tubular boilers set 6 ft. 6 in. to the bottom of the shell, and Stirling boilers set 3 ft. 6 in. to the center line of drum are equally smokeless.

So well worked out is this problem that the question of smokelessness seldom arises in a contemplated installation of chain grates. It is almost taken for granted that an installation of chain grates will be smokeless. Close observation of performances where chain grates are in use and a review of the records of the various bureaus for smoke prevention establishes the fact that chain grate furnaces have long since passed the point of being uncertain as to smoke. With the present boiler settings of more generous proportions, smokelessness is practically assured.

High set boilers are the result of the effort to secure complete combustion of our high volatile coals in the furnace. Test results taken through years of practice with high and low set boilers indicate that between heights of 7 to 10 ft. on vertically baffled boilers there is fully a 12 per cent difference in efficiency in favor of the latter. This difference is solely creditable to a more complete combustion of the hydro carbon gases.

Smokeless combustion was the first inducement that has led to the general discovery of the improved efficiency obtainable. It is well said that while smoke is not in itself a great loss, it is almost invariably the telltale indicator of other reprehensible plant conditions which entail losses often as high as 20 per cent.

The fuels which are customarily burned on chain grates are the bituminous, tarry, smoky coals, which without question are, under improper condition, the worst smoke producers obtainable. Chain grates are fortunately well adapted to these fuels and smokeless combustion is easily obtained. In the words of W. L. Abbott, chief engineer of the Commonwealth Edison Co. of Chicago, "Illinois and Indiana coals were originated to be burned on chain grates." Certainly smokelessness is easily obtained even with such fuels with chain grates and proper furnaces. The necessary dimensions for smokelessness with chain grates are standard in most of our cities. Arch designs, air distribution and air exclusion and other features are improving.

At one time an efficiency of 72 to 75 per cent with chain grates and western coals was considered impossible. Today such results are repeatedly obtained with proper furnace designs. Such results are due to complete combustion in the furnace. Stokers have in many instances been accused of being responsible for low economy, when as a matter of fact the loss was entirely due to a deficiency in furnace space. Many eastern coals, due to a lower percentage of volatile hydrocarbons, do not require the furnace volume required by our western coals. As an example, compare Pocahontas and New River with 12 to 14 per cent volatile, with Pittsburgh No. 8 at 35 per cent, more than double the amount, and yet there has been no discrimination of furnace to burn this greatly increased percentage of volatile. Illinois and Indiana coals have 35 per cent volatile and some Colorado coals have close to 60 per cent.

The message, therefore, which the writer would impress is:

(1) Learn to analyze furnaces as to the number of cubic feet of furnace per square foot of grate.

(2) High moisture fuels, sub-bituminous, lignite and Iowa high ash coals are now being successfully burned in many plants on chain grates, the problem being simply one of furnace design.

(3) There are comparatively few boiler settings existing today which could not have their efficiency improved several per cent with no change in apparatus, but by increasing the proportions of the furnaces.

(4) The writer would ask engineers to realize that departments of smoke prevention are asking for the minimum dimensions to insure smokelessness, frequently an appreciable improvement in efficiency is obtainable by installing still more ample furnaces. Best practice is in this direction.

(5) The plea, therefore, is for more ample furnaces and the higher efficiencies beyond the minimum required for smokelessness.

CONCRETE DEPENDS for its strength upon securing the highest possible density. With a given aggregate and the same quantity of cement, the strength of the concrete reaches its maximum with the smallest quantity of water that can be used to produce a plastic mix. Any increase in the amount of water is accompanied by a rapid decrease in the strength of the concrete.—Compressed Air Magazine.

WE HAVE nearly two million men in France.

Every subscriber to the Liberty Loan helped send them there.

Fuel Economy in Hand Fired Power Plants---II*

PRINCIPLES OF COMBUSTION—DRAFT

COMBUSTION of coal in a furnace is essentially a chemical process during which the combustible elements of carbon, hydrogen and sulphur unite with oxygen to form carbon dioxide, steam, and sulphur dioxide respectively. The air, which furnishes the oxygen for this process, consists of a mixture of 21 per cent by volume of oxygen and 79 per cent of nitrogen. Oxygen is the active element as affecting combustion, the nitrogen being inert and taking no part in the process.

When combustion takes place, heat is given off. For every pound of carbon burned to carbon dioxide, 14,600 B.t.u. are released. In the same way, for every pound of hydrogen burned to water vapor 62,100 B.t.u. are liberated. One pound of sulphur in burning to sulphur dioxide gives up 4000 B.t.u. The heat liberated serves to raise the temperature of the fuel bed, of the surrounding surfaces, and of the products of combustion. Part of the heat delivered to the water in the boiler is transmitted by direct radiation from the hot surfaces, and the rest is absorbed by conduction from the gases, thus

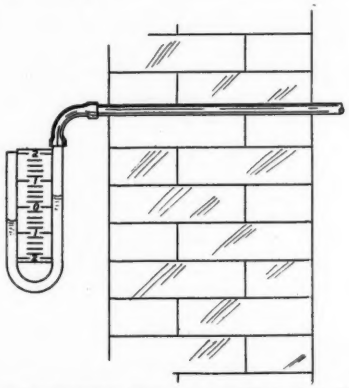


FIG. 1. MANOMETER TUBE FOR SHOWING PRESSURE DIFFERENCE

lowering their temperature. The heat carried away by the gases after they have left the heating surfaces of the boiler represents the loss entailed in the process. The extent of this loss is, of course, indicated by the temperature of the gases leaving the heating surfaces. The nitrogen, as stated, takes no part in combustion, but on the contrary it absorbs a certain amount of heat in having its temperature raised from that of the air to that of the gases leaving the fire. Consequently, the temperature of the other gases does not reach so high a point as would be possible if oxygen alone could be introduced into the fuel bed. When the nitrogen leaves the heating surfaces with the rest of the gases, it carries away part of the heat released by the fuel, and therefore, represents a loss amounting to about 0.24 B.t.u. per pound of nitrogen per degree F.

In the process of combustion, 1 lb. of carbon unites with 2.67 lb. of oxygen to form 3.67 lb. of carbon dioxide. Since the composition of the air is 77 per cent nitrogen and 23 per cent oxygen by weight, 2.67 lb. of oxygen requires 11.6 lb. of air.

One pound of hydrogen in burning unites with 8 lb. of oxygen to form 9 lb. of water vapor. In this case the amount of air required is 34.8 lb.

One pound of sulphur in burning unites with 1 lb. of oxygen to form 2 lb. of sulphur dioxide. The air required is 4.35 lb.

It is evident that if the weights of carbon, hydrogen, and sulphur in one pound of coal are known, the air necessary to burn completely 1 lb. of coal amounts to 11.60 times the weight of carbon, plus 34.80 times the weight of hydrogen, plus 4.35 times the weight of sulphur. This is about 12 lb. of air per pound of coal.

Every cubic foot of oxygen used in the combustion of carbon is replaced by one cubic foot of carbon dioxide. For this reason, the percentage by volume of CO_2 in the flue gas is an indication of the amount of excess air present in the furnace. A given amount of CO_2 will be formed for every pound of carbon burned. If just enough air is used for the complete combustion of the

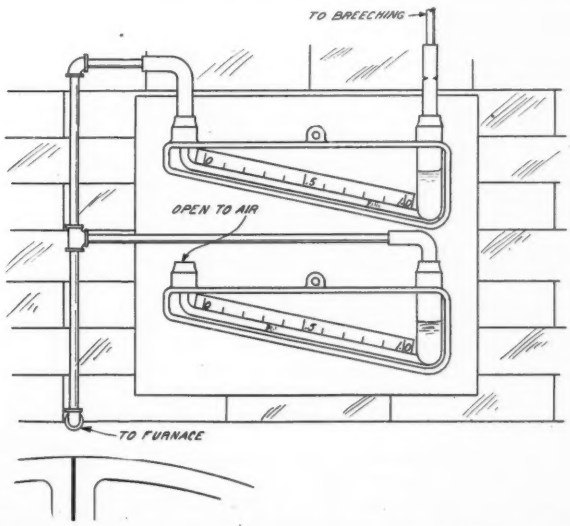


FIG. 2. CORRECT METHOD OF CONNECTING DRAFT GAGES

carbon, the oxygen will be replaced by the CO_2 formed and the latter will be the same percentage, by volume, of the mixture as the original oxygen. If twice as much air as necessary is used, the same volume of CO_2 will be formed as before, but this will replace only one-half of the oxygen used, and hence its percentage of the mixture will be only one-half as great as in the former case. These relations are somewhat affected by the fact that hydrogen and sulphur are present, but their amounts are too small to have an important bearing on the result.

If less than enough air is furnished for complete combustion, part of the carbon in the coal, instead of being burned to carbon dioxide, will form carbon monoxide. Under these circumstances the amount of heat liberated per pound of carbon, instead of being 14,600 B.t.u. will be only 4500 B.t.u. The difference, 10,100

* Abstract of Circular No. 7, entitled Fuel Economy in the Operation of Hand Fired Power Plants, published by the University of Illinois Engineering Experiment Station.

B.t.u., will represent the heat lost for every pound of carbon burned to carbon monoxide.

Since combustion is the result of the union of oxygen with the various elements in the coal, and with the combustible products formed in the fuel bed, it necessarily follows that in order to have complete combustion, each particle of these elements must come into contact with a sufficient amount of oxygen. To insure this contact between the particles of the combustible and oxygen, it is necessary to supply an amount of oxygen, and hence of air, somewhat in excess of the amount theoretically required; otherwise carbon monoxide will be found in the escaping gases. This excess acts as a further dilutent, and represents loss, just as the nitrogen in the air represents loss. A compromise must, therefore, be made. The correct amount of air to be used is obtained when

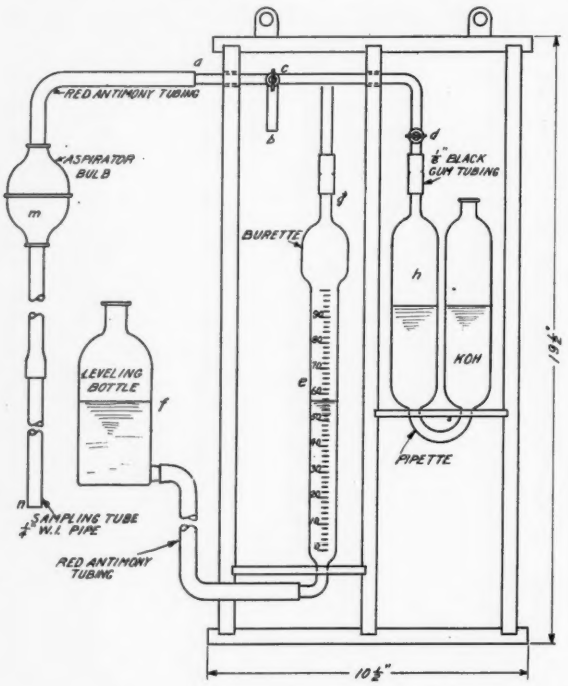


FIG. 3. APPARATUS FOR DETERMINATION OF CO_2 IN FLUE GAS

the loss due to heating the excess just balances the loss due to the carbon monoxide appearing if the excess is reduced. For best operating conditions it is found necessary to use between 30 and 40 per cent of excess air.

Before the union of oxygen and the elements in the coal can take place with sufficient rapidity to be of any practical use, it is necessary that the whole mass be brought to a temperature known as the ignition temperature. If, because of any condition, such as contact with the cold surfaces of the tubes or the inrush of an excessive amount of cold air, the temperature of the gases is lowered below the ignition point before combustion is complete, combustion will cease and part of the fuel will escape from the furnace unburned. This, of course, represents a loss.

The three fundamental conditions necessary for complete and smokeless combustion may now be stated as follows:

(1) A sufficient amount of air must be supplied.
(2) The air and fuel must be intimately mixed.
(3) The mixture must be brought to the ignition temperature and maintained at this temperature until combustion is complete.

Significance of Draft

The technical meaning of the term "draft" does not refer to the motion of the air or gases, but merely defines the difference in pressure existing between the air outside and the gases inside the furnace. If there is an opening into the furnace and the draft is maintained, air will be forced in from the outside. The amount of air which passes will depend upon the size of the opening and the resistance offered to the flow; hence the weight of air passing through the fuel bed from the ashpit for any given draft over the fire will depend upon the thickness of the bed, the size of the pieces of coal, and the condition of the bed. In any case, the combustion of a given amount of coal always requires a definite amount of air. Since for large pieces of coal the voids in the fuel bed are correspondingly large, a fuel bed of given thickness will present less resistance to the passage of air than a bed of finer coal of the same thickness. Hence it requires less draft with large coal than with fine coal to pass a given amount of air through the fuel bed. It is, however, advisable to use a thicker bed with large coal in order to close up the holes. This in turn will make it necessary to increase the draft to a point about equal to that used for fine coal, although the exact relation existing between thickness of bed, draft, and load on boilers must be determined by experiment in each case.

Every boiler should be equipped with two draft gages, one connected directly into the space over the fire and one connected both into the space over the fire and into the gas passage below the damper, giving the drop in pressure through the tubes and baffling. The operation of the boilers should be controlled by means of the draft over the fire. The draft necessary to carry any given load and the corresponding proper thickness of fuel bed with the grade of coal used should be determined. With everything in good shape and no leaks in the setting and a given draft over the fire, there should be a definite loss of draft through the setting, or differential draft as it will hereinafter be called. When the damper is opened to increase capacity, both the furnace draft and the differential draft will increase. Assuming that the correct thickness of fuel bed is being used, an increase in the differential draft reading over the normal reading with the given furnace draft indicates that there are holes in the fuel bed or that the tubes have become clogged with soot and ash. A decrease in the differential draft indicates that the fuel bed is dirty and that the resistance is greatly increased by ash or clinker, or that some of the baffling is down, causing a short circuit of the gases.

Significance of CO_2 in the Flue Gases

A study of the amount of CO_2 in the flue gases affords the only practical means of obtaining a knowledge of conditions existing within the furnace on the basis of which correction or regulation to obtain the best results may be made. Every plant should be

equipped with some form of CO_2 analyzing apparatus and the fireman or other employe taught to use it. Since it is comparatively inexpensive, the outlay will be returned many times by the gain in efficiency and the consequent saving of fuel. For this purpose an Orsat apparatus or some of its modified forms should be used. The complete Orsat apparatus provides a means of analyzing for carbon dioxide, oxygen, and carbon monoxide, but since the CO_2 values give a sufficiently accurate indication of the amount of excess air passing through the fire, the analysis for the other two gases may be omitted and the apparatus used in its simplest form, as shown in Fig. 5. This consists merely of a pipette, *h*, to hold the solution (potassium hydroxide), a measuring burette, *e*, of 100 cubic centimeters capacity, a leveling bottle, *f*, containing water, and an aspirating bulb, *m*. The solution may be made by mixing equal weights of potassium hydroxide (KOH) and water. In the absence of this chemical, concentrated lye may be used.

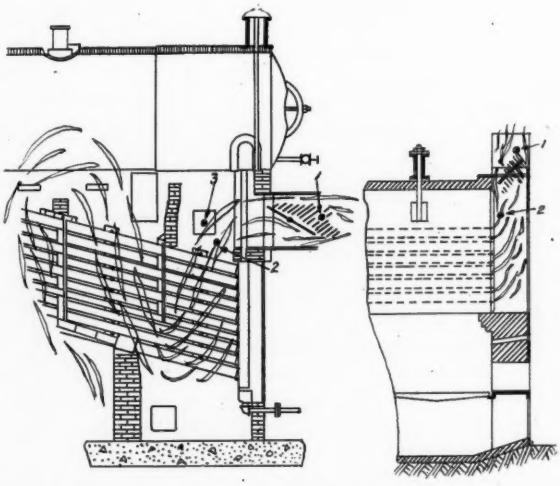


FIG. 4. SHOWING PROPER, POINT 2, AND IMPROPER, POINTS 1 AND 3, LOCATIONS FOR GAS SAMPLING TUBES

There are several precautions which should be observed in taking samples. There must be no leaks in the rubber tubing or connections. If air leaks in during the analysis, it invalidates the result. The sole object in making an analysis is to determine what the fire is doing at the time the sample is taken; hence the apparatus should be hung on the setting at a point as near as possible to the point where the sample is taken in order to reduce the amount of piping and rubber tubing between the sampling tube and the analyzer, and to insure a sample representative of conditions at the time. If the sample is conveyed through tubes of considerable size and length, as is usually the case with a CO_2 recorder or even with a CO_2 indicator, the analysis is made from 5 to 15 min. after the sample is taken. Thus a hole in the fire may be disclosed by the analyzer 5 or 10 min. after its initial occurrence and even after its disappearance by filling up. The CO_2 recorder, therefore, is useful for giving an idea of the average operation over a long period, but is not satisfactory as a means of determining the proper relation between load, draft, fuel bed thickness, and other conditions. The determination of such relations involves simultaneous readings.

For all practical purposes, it is best to take a sample through the end of a straight tube consisting of a piece of ¼-in. pipe so that the point of sampling may be known with accuracy. A sample taken from the center of the main gas stream where the gas has the greatest velocity has been found to yield an accurate indication of the condition of the fuel bed at the time of sampling, slight variations in the condition of the fire being reflected immediately in the sample. In placing the tube, care should be taken to have the end in the center of the main gas stream at point No. 2, Fig. 4, and not in any of the dead gas pockets as indicated by points 1 and 3. Otherwise low CO_2 values not representative of the actual conditions will be obtained. The tube should be inserted at the point where the gases leave the heating surfaces of the boiler for the last time as indicated by point 2 in Fig. 4, and not further out in the flue. An iron tube should not be used if the temperature at the point of sampling is sufficient to raise it to a red heat, because the character of the sample may be affected by part of the oxygen in the sample uniting with the red hot iron. A small cotton filter, contained in a glass tube, should be inserted between the sampling tube and the aspirator bulb.

The Importance of Saving Waste Paper

WASTE paper of all kinds can be used in making new paper or paper boards. All the chip board from which ordinary pasteboard boxes are made is manufactured out of mixed waste paper scraps gathered up in the stores and other places. Newspapers make a better grade of board known as news board. Strong wrapping papers mixed with sulphate pulp are used in making test or strong chip board from which shipping containers of all kinds are made. These are taking the place of wooden boxes, thereby conserving the forests.

The finer grades of waste paper such as old magazines, books, stationery, etc., are sorted out, de-inked, and used again in making books, writing and other grades of paper. In making boards and ledgers, etc., a considerable quantity of rags are necessary, the supply of which is becoming very scarce. It is imperative, therefore, that all old rags be saved. Every household should save all of its old paper and rags as well as old rubber, leather, etc., and dispose of them to the school children, Salvation Army, junkmen, or other collectors, so that the supply may be kept adequate to meet the demands of the government and other essential uses.

U. S. CIVIL SERVICE COMMISSION announces an examination Oct. 22 for fuel inspection engineer to fill vacancies in the Bureau of Mines, Washington, D. C., at $1620 a year. Competitors will be rated on general education, training and experience in fuel work, and on essay (to be submitted with the application). Applicants must submit their photographs. Apply for Form 2118, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.

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Improving Factory Steam Plants---IV

PLANT NO. 3 IS TAKEN UP IN THIS INSTALLMENT; STARTING WITH FAIRLY HIGH EFFICIENCY TESTS ARE MADE UPON WHICH RECOMMENDATIONS ARE BASED. BY H. A. WILCOX

THIS case was radically different from the two preceding cases, in that the steam plant was apparently running at fairly high efficiency to begin with. In addition to steam pressure drops, there was another factor which brought about the investigation: The entire mill was owned by one firm, but there were two distinct departments in the mill, each having an entirely independent organization from the other. In fact, one department worked on the production of woolen goods and the other on cotton. The steam plant, however, supplied both departments with power and steam for manufacturing purposes.

For the sake of illustration, in this article I will call the woolen department plant X and the cotton department plant Y. Plant X paid all the bills for the steam plant and charged plant Y a certain portion of them for its use of steam. Trouble was experienced with frequent steam pressure drops and plant Y management felt that a more exact basis of charging off the expense of the steam plant ought to be arrived at. I was therefore called upon and instructed to investigate and report with recommendations.

As I followed out my usual system of investigation, as outlined in cases I and II, it will be unnecessary to bore the reader with details.

I will therefore set forth the information embodied in my reports and this will show exactly how the problems were solved. To simplify the matter, I will give the reports substantially as they were written, although not quoting them verbatim:

In this report, the boilers and accessories will be taken up under the following headings: 1. Brief description, 2. Organization, 3. Operation, 4. Tests, 5. Criticisms, 6. Recommendations.

1. DESCRIPTION

THE BOILER plant consists of four horizontal return tubular boilers. I have considered them as numbered from left to right (1, 2, 3 and 4) for the purposes of this report. Numbers 1, 2 and 3 are 25 yr. old and number 4 is 21 yr. old. (Information obtained from the Boiler Insurance Co.)

Rated horsepower of each boiler (as near as can be ascertained) 125. Heating surface each boiler 1250 sq. ft. Grate area each boiler (5×5.5) 27.5 sq. ft.

Ratios: Heating surface to grate area = 45.5 to 1. Square feet grate to one boiler horsepower = 0.22 to 1. Heating surface to one boiler horsepower = 10 to 1. Each boiler has 72 3½-in. tubes 18 ft. long. The boilers are equipped with Morse shaking grates. The safety valves are set to open at 125 lb. per sq. in.

Soft coal, having a heat content of about 14,650 B.t.u., is used and is wheeled from railroad cars to the boiler room, a distance of about 500 ft., in a one-horse tip cart, having a capacity of about one ton. The cart is backed into the boiler room and the coal dumped on the floor in front of the boilers. Enough coal is put in during the day to last all night. Ninety per cent of the coal placed in the boiler room is charged at the end of each week by plant X against plant Y. The loads are not actually weighed, but each load is assumed to contain 2240 lb. of coal.

Ashes are raked out from under the boilers and wheeled out and dumped near the stack by means of wheelbarrows. Large clinkers are thrown in a small concrete bin just outside the boiler house. After the tip cart has hauled enough coal into the boiler room to last all night, it is used to haul away ashes. This tip-cart does not belong to the firm, but is hired from an outside contractor at $5 a day.

The main flue runs across the top of the boilers to the stack and in addition is connected to the economizer flue. As the economizer is not in use at present, its flue is blanked off from the main flue. The boilers are equipped with individual hand operated dampers and a main damper, equipped with a damper regulator, is also located in the main flue near the stack. The damper regulator is operated by hand, as it opens too slowly. The stack is 152½ ft. high, built of red brick, octagonal in shape, one side being 5 ft. 6 in. wide, and the sides are about 6 ft. thick at the base.

As the economizer is out of use and is in no condition for operation at present, it will not be considered in detail. It will be mentioned again further along in this report.

Natural draft is used, its force in the flue averaging about ½ in. of water.

Feed water for the boilers is obtained from a receiver tank located in the basement adjacent to the boiler room. The water in this receiver comes from trap returns throughout the mill and make-up water is supplied from the city mains. At certain times of the year, feed water may be drawn from an old barge canal which is located near the mill. The water in this canal is seldom clean enough for this use and moreover contains certain impurities which have been found to be detrimental to the boilers; therefore its use for feed water has been practically discontinued. The feed water is pumped by a duplex pump, size 7½ by 5 by 6 in., through a closed feed-water heater into the boilers. In emergency, two injectors may be used. These injectors draw their supply of water from a catch basin connected to the canal, mentioned above. As stated previously, the feed pump is also piped up to draw from this catch basin.

A feed water meter has been recently installed in the feed line for obtaining the rate of flow of the feed water and the amount used per day.

Williams feed water regulators and water columns are installed on boilers Nos. 1, 2 and 3; No. 4 feed is regulated by hand.

A 2-in. blowoff pipe runs from the back end of the shell of each boiler, and connects to the blowoff line which runs to the blowoff tank and from there to the river. Each blowoff pipe has a single cock and a small connection is made from the steam main to permit blowing steam backward through the blowoff pipes, in order

to clear them. This is done only on a boiler which is let down for cleaning.

Each boiler has a single 3½-in. pop safety valve set to open at 125 lb. pressure.

A 10-in. steam pressure gage reading from 0 to 200 lb. is installed, one to each boiler, on boilers 1, 2 and 3. No. 4 has a gage reading from 0 to 160 lb.

A draft gage of home manufacture has recently been put into operation to obtain the draft in the flue, ash-pit, and over the fire on any of the boilers.

There is the usual equipment of firing tools, namely, rake, slice bars, hoes, and scoops. There is also a tube blower and tube cleaner.

2. Organization

The operating force consists of the master mechanic of plant X, who has entire charge of the power department; two day firemen and two night firemen, who look after the engine, feed pump, etc.; one day ashman, and a driver and helper for the coal and ash cart, mentioned previously. There is apparently no head fireman, although one of the day men has fired here for 17 yr. and is regarded somewhat in that light. I understand that 90 per cent of the pay of nearly all the above force is charged by plant X against plant Y.

All repairing, renewing, etc., in the power plant is generally done by the master mechanic of plant X and his men and then 90 per cent of the cost charged against plant Y.

3. Operation

There is practically no system whatever in the boiler room. At the beginning of each shift the men start cleaning the fires, commencing at No. 1 and working toward No. 4. The hot ashes from cleaning are allowed to lie under the grates for some time. One man takes care of Nos. 1 and 2 and the other takes care of Nos. 3 and 4. Intervals between firings vary between 20 and 30 min. and the amount of coal thrown on the fires varies between five and nine scoopfuls. The fires are occasionally sliced and shaken. Both men usually fire or slice the fires at the same time. The water regulators being out of commission, the feed water is regulated by hand and the height of the feed water varies from about 3 in. in the glass to high water. No attempt is made to keep the feed water flowing into the boilers at anywhere near a uniform rate.

Every week end, a tube cleaner is run through the tubes and one or more of the boilers are blown down and washed out. All the boilers are blown down a very small amount once each day. Frequently, during the day, large quantities of wood, rags and other rubbish are thrown into the ash pits and burned. After the fires are cleaned, water is generally put into the ash pits of boilers 2, 3, and 4 by means of a hose. The hose will not reach to No. 1 boiler, so no water is put in its ash pit. The catches are broken on several of the fire doors and they have to be propped so they will not swing open. Occasionally a prop will fall down after a firing and the door will swing open for a few minutes until the fireman happens to notice it and shuts it. I have seen this happen and a fire door remain open about 5 min. before the fireman saw it and closed it. The operation of machinery outside of the boiler room will not be considered in this report.

4. Tests

I have run a number of short evaporative tests on this battery of boilers since the installation of the feed water meter. These tests were all taken as follows:

Data—Alternate Method

Feed water measured by meter. This meter has been tested and is correct to within 3 per cent. Water line on all the boilers is determined by strings and measurements at the start of each test and brought to the same level at the end of each test. Coal weighed out in about 250-lb. lots as fired. Readings of steam pressure, feed water meter, feed water temperature, and draft taken every 15 min. Flue gas temperature and temperature of air in boiler room taken every half hour. Blowoff pipes not blanked, but blowoff cocks locked shut. No special instructions to firemen. Tests 1, 2 and 4—fires cleaned just before starting tests. Test 3, fires on Nos. 1 and 2 cleaned before starting test and fires on Nos. 3 and 4 cleaned during test, as would be done on ordinary running conditions. Tests 5 and 6, all fires cleaned during tests, as would be done under ordinary running conditions; in fact, every effort was made to test the boilers under their regular system of operation. The coal was composed of an approximately equal mixture of small lumps and slack. New River Pocahontas and Long Branch coals were used; it was impossible to determine in what proportions they were mixed, as the coal had been dumped promiscuously down a side hill

Test No.	1	2	3	4	5	6	Weighted aver. of all tests
Date	4/16/16	4/19/16	4/19/16	4/22/16	5/2/16	5/4/16	---
Duration (hr.)	6	3	4	4	9	12	---
Weather	fair	fair	fair	rain	fair	fair	---
Average steam pressure (lb. per sq. in.)	115.4	111.0	111.4	107.7	110.4	105.5	109.1
Av. feed water temperature (degrees F.)	182.7	180.9	178.0	189.5	173.5	174.5	177.9
Av. temperature of flue gases (degrees F.)	(No pyrometer available)				465.1	484.4	476.1
Av. temperature of air in boiler room (degrees F.)	(No thermometer available)				77.5	75.3	76.2
Av. draft in flue (in. of water)	----	----	----	0.65	0.56	0.45	0.52
Av. draft over fire (in. of water)	----	----	----	----	0.44	0.31	0.37
Av. draft in ashpit (in. of water)	----	----	----	----	0.31	0.14	0.21
Total water fed to boilers (pounds)	116,400	27,500	72,656	70,800	164,012	236,520	----
Total coal as fired (pounds)	10,621.5	3,960	7671.5	7196	16,997	23,671	----
Actual evaporation corrected for quality and water level	10.74	7.00	9.29	9.64	9.50	9.59	9.56
Total equivalent evaporation from and at 212 deg. F.	122,680	29,026	76,915	74,100	175,851	247,828	----
Equivalent evaporation from and at 212 deg. F. per pound of coal as fired	11.55	7.54	10.06	10.30	10.51	10.38	10.35
Equivalent evaporation from and at 212 deg. F. per square foot of heating surface per hr.	4.09	2.90	3.65	3.71	3.89	4.13	3.92
Coal burned per square foot of grate surface per hour	16.09	17.50	17.44	16.35	17.17	16.09	17.35
Boiler horsepower developed per hour A.S.M.E. rating	592.4	420.5	557.1	556.7	564.3	598.5	568.3
Thermal efficiency of boiler plant per cent	76.5	49.9	66.4	68.2	68.5	68.7	68.5

Remarks

Necessary assumptions made for figuring results in all six tests:
1. Quality of steam, 98 per cent.
2. Barometer, 14.7 lb. per square inch.
3. 14,650 B.t.u. per pound of coal as fired (from previous tests)

from the railroad cars on a siding at the top of the hill. The average density of the smoke emitted during all six tests was about equal to a No. 1 Ringelmann chart.

Fires varying in thickness from 8 to 10 in. were carried on all the tests. On test No. 6 a total of 7.4 per cent of ash was obtained. This percentage is somewhat high, doubtless due to the fine coal which sifted through the grates when the fires were cleaned. Several items are omitted under tests 1, 2, 3 and 4, such as flue gas temperature, etc., on account of lack of instruments at the time these tests were run. The analysis of the flue gases is entirely omitted because the orsat was not available for use until test No. 5 was run and also on account of air leaks from the economizer flue, near the only available place for the sampling pipe, which gave absolutely incorrect analyses. An unsuccessful effort was made to plug up these leaks at the time the tests were made. Before test No. 7 is run, in accordance with recommendation No. 1 under "Tests" (refer to later point in this report) the location of the sampling pipe will be changed to the uptake of boiler No. 2 so that an accurate series of flue gas analyses may be obtained. This test will be reported in a supplement to this report.

5. Criticisms

A. The boilers: For purposes of comparison a table is given below, showing how closely the boiler measurements approach the accepted standards of good design.

	Sq. Ft. Heating surface per sq.ft. of grate	Sq. Ft. of grate per boiler horsepower	Heating surface per boiler horsepower	Rate of Combustion
Standard practice	35 to 40	0.30	11.5	8 to 15
This plant	45.5	0.32	10.0	16.09 to 17.50 (Tests)

The ratio of heating surface to grate area is quite high and so a high rate of evaporative economy might be expected. The rate of combustion, however, is also high and this would tend to offset the advantage due to high ratio of heating surface to grate surface. Assuming that the rated horsepower of the boilers is 125 each, then the highest percentage of rated horsepower developed in any of the foregoing tests was 119.66 per cent each, which would not indicate that the boilers are being forced very hard. The remaining two columns in the table above approximate standard conditions and will not be discussed here.

B. Coal: Ninety per cent of the total coal placed in the boiler room is charged against plant Y, and the coal is not weighed in any way except by the number of loads, each one assumed to weigh 2240 lb. The record of the number of loads brought into the boiler room is kept on a small blackboard in the boiler room by the ashman. I have noticed that he frequently forgets to mark down a load until after the cart has been dumped and has been gone for some time. This leaves a chance for a large error to occur either way, in the coal used, and a means of weighing the coal used accurately should be devised. At the beginning of test number one, I weighed several loads of coal at irregular intervals, obtaining the following weights per load: 1715 lb., 1913 lb., 2043 lb. net. The driver of the team made a special effort and heaped up the third load to see if he could put on a full 2240 lb. It will be seen at once that the first two loads were far short of 2240 lb. and that the third load did not total 2240 lb. even when the driver made a special effort to put on all the coal possible. As plant Y pays 90 per cent of 2240 lb. on each load, it may readily be noted that plant Y is paying for all of the coal used in the boiler room and at times even more than is used. Moreover, a very large cumulative error is certain to occur, making the record of coal apparently consumed by the boilers larger than it should be. As a check upon this reasoning, the office records of coal were recently inspected. According to these records, containing the amount of coal received at the mill and the amount of coal used by the boilers, the coal bin should have been practically empty. An examination and measurement of the coal in the bins showed two or three hundred tons of coal on hand. The records in question covered a period of about four months. Further comment is needless.

C. Ashes: In my opinion, the handling of the ashes is carried out as efficiently as possible, without the use of expensive machinery. D. Flue: As previously mentioned, the economizer is out of use and its flue is blanked off from the main flue. Upon application of a draft gage to the economizer flue, considerable draft was indicated, showing there is still air leakage from the economizer into the main flue. The damper regulator should be automatic in operation instead of being worked by a rope pulled by the fireman.

E. Economizer: The economizer is out of repair and before operating it again it will be necessary thoroughly to overhaul it and bore all the tubes. This would probably cost more money than the economizer is worth.

F. Draft: The chimney is very high and is of ample size. Therefore the draft in the main flue is very good in spite of the air leaks mentioned under D.

G. Feed water: The feed water pump was in very poor condition about a month ago and some doubt was entertained as to whether its capacity was large enough for its present work. Upon examination, it was found that the coil of the feed water heater leaked, as mentioned previously, and that the pump had been forcing part of the feed water out into the river. The heater was immediately bypassed and two of the valves on the pump repaired. Since then, no difficulty has been experienced with the feed water, except that when the water gets too hot, as it frequently does throughout the day, the pump races badly. It then becomes necessary to cool down the pump supply water in the receiver tank, before the pump will work properly again.

H. Feed water meter: The meter has not as yet given entire satisfaction. When first set up, it was observed that it had been subjected to hard usage somewhere and a man sent by the builder had to re-fit it entirely.

The first four evaporative tests as above were run after the meter had been re-fitted and during each test something went wrong with the meter. Owing to the fact that frequent balances were made during the tests, only a reasonable doubt exists as to the absolute accuracy of the economic results of the tests. After the meter was repaired more check tests were run as will be noted later on.

I. Feed-water regulation: Although feed-water

regulators are installed on three of the boilers, they are not in working order and feed regulation is by hand. This makes the water level and rate of feed somewhat erratic.

J. Blowoff: The blowoff pipes are in poor condition and need a thorough overhauling. There is only a cock on each one and the nipples on Nos. 2 and 3 blowoffs are liable to rupture at any time.

K. Safety valves: The safety valves are all in good shape mechanically, but there is no system for testing them to see that they are always in proper working order.

L. Steam gages: O. K. except for a maximum difference of 4 lb. between the readings of all four.

M. Draft gage: Homemade and serves its purpose.

N. Firing tools: O. K. except that there is no hose for tube blower.

O. Organization: From all that I have observed up to the present time, the operating force is large enough and fairly well organized. It would perhaps be as well to place one of the men in charge as head fireman on each shift. He would be under the master mechanic and would be responsible for the entire power department on his shift, although he ought not to be allowed to hire and discharge the men under him just at present.

P. Operation: In my opinion the method of operation can be improved upon, especially in regard to firing, cleaning fires, etc. I consider it bad practice to coal or rake two fires at the same time in a battery of only four boilers. It does not improve the lining and bridge wall of a furnace to knock off clinker by throwing the end of a heavy slice bar as hard as possible against it, and, moreover, a lot of cold air enters the furnace while this is being done. Burning large quantities of rubbish in the ash pits materially lessens the life of the grates. It is almost impossible to get rid of the accumulation of loose scale at the back ends of the boilers, unless the blowoff cocks are opened wide and the boilers blown down about one gage for every 6 hr. of regular operation. A boiler cannot be expected to do efficient work unless the tubes are blown at least once in every 24 hr. of regular operation. If any regard is to be held for "Safety First" methods, all water columns should be blown down and the try cocks tested at least twice a day and the safety valves tested regularly at least once each week. There are other things, such as cleanliness, system, regularity, etc., which could be bettered and will be mentioned under "Recommendations."

2. Tests: Judging from the economic results of the tests, with the exception of test number two, it would appear that the boilers are being operated at good efficiency. There are, however, several factors which have an influence on these results. 1. An error of about 2 per cent should be allowed for water leaking from the blowoff pipes. An error of 1 per cent should be allowed, due to trouble with the feed-water meter, i. e., leaks, slipping of integrating counter, and air in the piping. 3. An internal inspection of No. 1 boiler showed a large amount of loose scale lying at the rear end of the shell, some of it being ¼ in. thick. Shortly before the tests were run, a large amount of caustic was accidentally introduced into all the boilers through the feed piping. There is little room for doubt but that this caustic loosened up the scale which would have otherwise caused a loss in heat conductivity of the metal perhaps as high as 15 per cent. The examination showed that the boiler was clean otherwise, except for scale which was bridged across the tube ends at the rear.

On the whole, the average of all the tests together is probably as nearly an accurate indication of what the boilers are doing, as can be obtained. A few short check tests were subsequently run and will be reported later on.

Recommendations

A. Boiler room: Windows should be washed; pipes and boilers brushed off, and all dirt and rubbish cleaned out at least every two weeks. The coal bin should be enlarged by moving its back side 2½ ft. nearer the west wall of the room. This will give a larger coal storage space and will permit storage of enough coal to last all night without getting the pile so close to the firedoors that the firemen have to stand in coal up to their knees for the first few hours when tending their fires, as is the case at present. The firedoors and the boilers themselves are set too low. The centers of the firedoors are 34 in. above the floor, but, due to the overhang of the boiler fronts, the fireman has to stoop very low in order to see the whole fire and cover any holes there may be. He is, therefore, in a very cramped position for throwing on coal. As a result, most of the time the coal is thrown on promiscuously and very little trouble is taken to look for and cover holes. Unless new boilers are contemplated in the near future, the boiler room floor should be lowered about 10 in. along all the front of the boilers in order to obviate the above difficulty. A line of electric lights should be installed above the tops of the boilers, back of the flue and about on a line with the manholes. These lights should be controlled from the boiler room floor and would enable a man to get to the junction valves in a hurry, in case of emergency, without danger of falling.

B. Boilers and accessories: The boilers are very old and it is only a question of time before the insurance company will begin to cut down the pressure allowed on them. The blowoff piping on all the boilers is in bad condition and should be thoroughly gone over and renewed where at all necessary. A valve, in addition to the blowoff cock, should be installed on each blowoff connection. The installation of this valve should be made in accordance with standard boiler practice. As the boilers are not equipped with nonreturn valves, a light iron ladder on the side of No. 1 should be installed to enable a man to reach the junction valves quickly. At present, a wooden ladder is used for this purpose and it is seldom in position when wanted. As the junction valves are at the top of the expansion bends, they are too high to permit of their being operated by a man standing on the boiler tops. A raised platform with steps should be put up to make these valves readily accessible. A small ladder is used now. Recently one of the men stepped on the top of one of the back arches and knocked a large hole in it. A light removable iron grating over these arches would prevent the recurrence of this thing. The hole mentioned above went unnoticed for several days, thereby greatly impairing the efficiency of the boilers.

All catches and baffles on the firedoors should be fixed at once in order to prevent the inrush of cold air and

warping of the doors. Some of the combustion chamber doors are warped and must be repaired or replaced. At the same time, a double thick wall of loose brick should be placed within the doorway to keep the intense heat away from the doors and so prevent a recurrence of this trouble. The setting and flue connections on each boiler should be carefully inspected and repaired to prevent air leaks. One boiler should be opened up each week, thoroughly examined, carefully repaired if necessary, and be thoroughly cleaned both inside and outside; this includes the removal of soot from the tubes and combustion chamber. This work can be done during the summer months when the demand for steam is the least.

By a judicious use of steam and proper handling, I believe that three boilers can carry the load, while the fourth is being repaired. The boilers should then be in good condition for another winter and a probable saving in coal consumption will be immediately effected. The feed-water heater should be repaired and placed in operation at once, as the feed-water temperature is low. By accurately weighing the coal and ashes, a constant check on boiler efficiency will be available and accurate charges for coal may be made against plant Y. The economizer and its flue should be removed, as they are not worth repairing and cannot be operated in their present condition. In addition, considerable air leaks through them and cuts down the draft in the main flue. The damper regulator should be repaired and put into operation at once. The feed-water regulators should be placed in proper working condition and be maintained in that condition. I understand that a regulator for No. 4 boiler is on the premises and it should be installed immediately. All steam gages should be tested and set to read correctly.

C. Operation: All tubes should be blown; boilers blown down one gage; all try-cocks tested, and the water columns blown down at least twice every 24 hr. An effort should be made to maintain a more uniform flow of feed water. The stack and flue should be cleaned out once a month and no rubbish should be burned under the grates. As the rubbish is composed largely of paper tubes, and paper stock is worth about 50c a hundred weight, it would seem worth while to bale and sell these tubes instead of spoiling the grates by burning the tubes under them. Scrap wood from the carpenter shop and other sources should be sold to the employes for firewood, as is done in other plants. In other words, the boilers are machines for the production of steam by means of the combustion of coal. They are not and never should be utilized as rubbish burners. Hot ashes should be removed as soon as the fires are cleaned in order to prevent damage to the grates. Water should be kept in all the ash pits at all times except when the fires are being cleaned. This will assist in preventing the formation of clinkers and will preserve the grates somewhat. The furnace walls and bridge walls are heavily coated with clinkers and a little common salt thrown on them each time the fires are cleaned will rot them so that after a treatment of from 40 to 60 hr. duration the clinker will come off readily. This treatment should be repeated as often as the clinker begins to attain any sizable proportions on the walls. Firing should be more uniform; no two fire doors should be opened at the same time receiving coal, slicing, or smoothing fires; all fires to be shaken gently once or twice per shift, and every effort should be made to avoid the use of the slice bar, as it only tends to aggravate clinker trouble.

D. Tests: 1. A test or number of tests should be run on the boiler plant with plant Y load only in order to determine accurately the percentage of coal, labor, repairs, etc., chargeable against plant Y.

2. Various methods of firing and thicknesses of fires should be tried and short tests run in order to determine the best firing system and thickness of fire to adopt.

3. After all possible improvements have been made, a set of rules, governing the maintenance and operation of the boiler plant should be placed in operation for the guidance of the man in charge of the plant and he should see that they are lived up to. A daily log, giving the important features of each day's run should be filled out and sent to the central office in order that a constant check upon plant operation may be obtained.

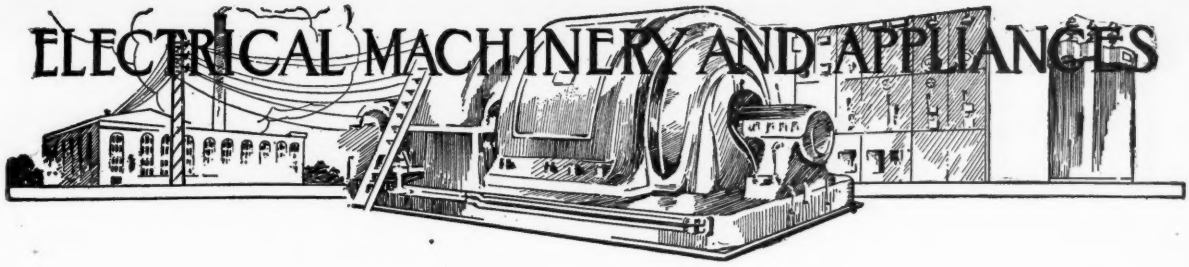
Finally

The advisability of the installation of a new boiler plant in the near future should be considered, as the cost of placing the present plant in first-class condition will be very heavy. It would seem desirable that a new boiler house be erected close to the present coal storage. This would involve the erection of a new stack, but would save the present charge of about $5 per day for teaming coal, as adequate provision could be made for unloading the railroad cars by gravity directly into the new boiler house. Other advantages would be again in floor space, where the present boiler plant is located and the fact that the plants would not have to shut down or slow down while new boilers are being installed.

The writer estimates that it would cost about $20,000 to build the above new boiler plant, including chimney, water-tube boilers, etc.

"Torcrete" is a reinforced concrete specially prepared for ship construction and is said to bear about the same relation to ordinary concrete as rolled steel does to cast iron. Instead of being poured in forms the materials are shot in place by means of compressed air with a "tector," a new type of concrete blower. The processes are the invention of a Mr. Weber. The preparation is discharged on layers of steel fabric or wire mesh, and there may be as many layers as is necessary to produce the required thickness, the layers themselves massing with one another so as to form a perfect solid. It is claimed the torcrete vessels are lighter than wooden ships, built in shorter time and at lower cost than any other type of concrete ships, and that the method of construction is adapted to any size of craft or any form of metal that may be desired.—Philadelphia Public Ledger.

Manufacturers of cement have been restricted by the U. S. Fuel Administration to using fuel during 1918 for not over ¾ of their average annual output for the years 1915, 16, 17. Exceptions are made where the cement is for government use or for buildings of public necessity, but special permits must be secured in such cases.



Service-Restoring Relay System

NOVEL SCHEME INSURING MINIMUM INTERRUPTION PERIODS

A NEW service-restoring relay system has been tried out for a number of months on the lines of several central station companies of considerable size, and the reports received have been satisfactory.

The system minimizes interruptions caused by transient short circuits, which clear themselves as soon as the circuit-breaker has been opened, thus permitting the feeders to be immediately put back into service. If the circuit-breaker is reclosed automatically within a second after the transient trouble has occurred, the service will be restored in time to prevent induction motors from stalling.

The Westinghouse service-restoring relay system has been developed to perform this operation within the shortest possible time and thus reduce all disturbances to a minimum, thereby greatly improving the lighting service. Should a permanent defect occur, the system will allow the breaker to remain open until the defect is cleared.

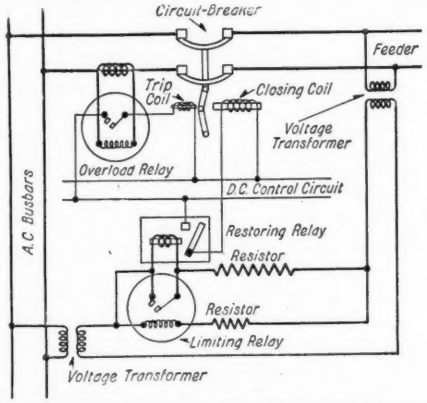


FIG. 1. SCHEMATIC DIAGRAM OF CONNECTIONS OF SERVICE RESTORING RELAY SYSTEM

A schematic diagram of operation is shown in Fig. 1. Any type of overload relay may be employed to trip the circuit breaker. A voltage transformer on the feeder outside the circuit breaker is connected so that its potential opposes that of another voltage transformer connected to the bus-bars. The restoring relay which is similar to a magnet switch, is connected in series with these two voltage transformers. Before a short circuit occurs, both voltage transformers are subjected to the same condition so that no current will flow through the restoring relay; but when a short circuit occurs and the circuit breaker has been opened by the overload relay, current will be forced by the bus-bar transformer into the feeder transformer through the restoring relay.

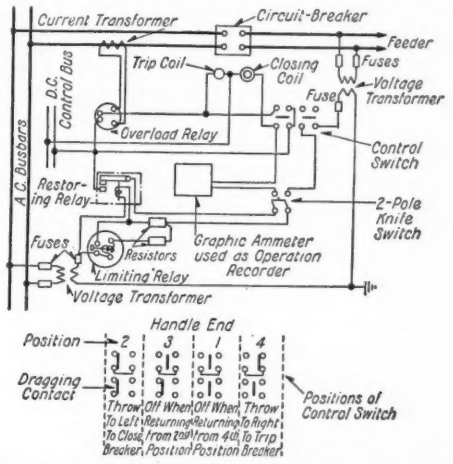


FIG. 2. COMPLETE DIAGRAM OF CONNECTIONS OF SERVICE RESTORING RELAY SYSTEM

The restoring relay will then close its contacts, which, in turn, will close the circuit-breaker.

In case of a permanent defect on the feeder, the restoring relay would continue to open and close the circuit-breaker indefinitely. To prevent this, a limiting relay, similar to the Westinghouse type CV overvoltage relay but equipped with weaker spring and heavier

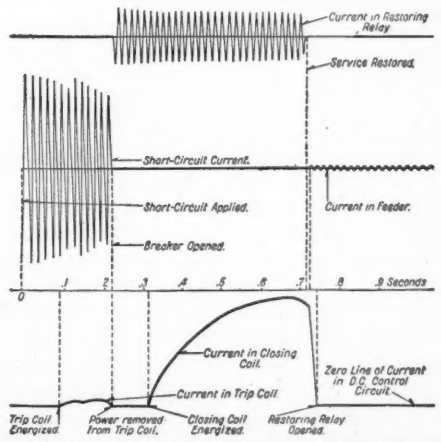


FIG. 3. OSCILLOGRAPH RECORDS SHOWING OPERATION OF RELAY SYSTEM ON A TRANSIENT SHORT CIRCUIT

damping magnets so that its action is sluggish, is connected in such a manner that while the circuit-breaker is open it is subjected to the same difference of potential

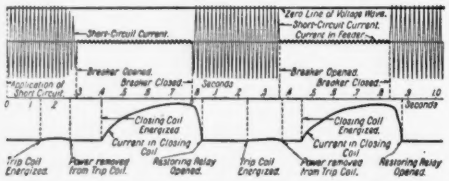


FIG. 4. OSCILLOGRAPH RECORDS SHOWING OPERATION OF RELAY SYSTEM ON A PERMANENT SHORT CIRCUIT

that is operating the restoring relay. Every time the circuit-breaker opens, the limiting-relay contacts begin to close and, due to its heavy damping, they do not return to the starting point immediately after the circuit-breaker is closed. After the circuit-breaker has opened and closed a predetermined number of times, this relay closes its contacts, thus short-circuiting the restoring relay and preventing further operation.

When this system is installed at substations having no attendant, it is often found advisable to have an indicating device that will show when the service has been momentarily interrupted. For this purpose a graphic ammeter is placed in the direct-current control circuit of the circuit breaker. This will indicate whenever the breaker has been closed by automatic means.

A special control switch is used, which contains one dragging contact so arranged that when the circuit-breaker is tripped manually the switch automatically opens the circuit between the two voltage transformers.

The service-restoring relay outfit is a valuable addition to the protective equipment of all central stations, and right now it should be especially useful, as it decreases power interruptions, and thus economizes the time of switchboard and other station attendants, or in some cases releases some of these men for other duties.

Electrical Plant in Steel Works

POINTS TO BE CONSIDERED IN THE SELECTION OF MOTORS, CONTROLLERS AND MAGNETS. BY MARK MEREDITH

USES to which electricity can be put for the driving of steel works plant are well known, and it is not here proposed to seek new converts to electrification. But what is wanted to promote the most successful application of electricity in steel works is a better and more thorough understanding of the conditions prevailing and their bearing upon the design, construction, and installation of the various plant details.

It is futile for the average electrical engineer who has never studied steel works conditions to attempt to design or issue specifications for plant to be used therein. Failure is certain. On the other hand, it is of the highest importance that the steel works engineer, in deciding upon the quotations for a particular piece of plant, should proceed intelligently and make absolutely sure—first, that what he is asking is the proper type for steel works use; second, that he is being offered such plant by the manufacturer; and third, that the details of the plant are such as to assure successful working under the stringent conditions imposed by steel works practice.

To recount briefly the scheme of operations in a modern steel works, the scrap and pig arrive in trucks and are unloaded by magnet cranes either into the stock yard or into the charging boxes. In the former case, there is the additional operation of removing from stock as desired and transporting to the charging boxes. The railway siding that brings in the trucks runs parallel to the line of furnaces, and between the railway and the furnace mouths run one or more charging cranes which transfer the charging boxes to the furnaces, upset them, and return the empty boxes to be refilled. The ingots, after being cast, are transported to the rolling mills, where they are reduced to the various sections required. From the start, there is an atmosphere of incessant activity. The plant is at work day and night, and the machinery is in many instances running continuously.

The electrically-operated charging machine which conveys the charging boxes has as many as five controllers all operated by one man. He has to run the machine up and down the line of furnaces, push out the arm of the machine horizontally to engage the charging boxes give it a vertical lift, slew the machine round through 180 deg. to empty the contents into the furnace, pull in the arm again, and reverse the process. These operations are not carried out singly, and two controllers at least may be working at one time to give their special motions. By electrical operation the speed of the cycle has been reduced to a very few seconds, and it is scarcely believable how quickly an operator can in so so short a time move five controllers through their cycles. But while admiring the celerity with which operations are carried out, the electrical engineer must direct his attention to the extreme robustness which must be characteristic of the electrical plant in order to enable it to withstand such rapid action.

As a further example, take the rolling mills. These are driven by large electric motors of extremely strong construction, and the ingots are conveyed to and from the mill after their various passes by rollers driven by special "live-roll" motors. A good criterion is obtained of the severe duty imposed upon the electrical plant in steel works when it is understood that often these motors are called upon to stop, start, and reverse something like 500 times an hour. If one of them breaks down, putting a train of rolls out of action, the mill may be stopped. It is therefore imperative that in the event of a breakdown the motor should be capable of instant repair. Further the machine should be readily accessible for inspection.

The line taken in the construction of these motors in the case of the continuous current machine has been to split the shell so that the machine can be opened out in a few minutes and the armature removed for inspection, giving at the same time access to the field coils. In this way the continuous current live-roll motor is similar to the standard traction motor. In the alternating current machine the problem has been more difficult of

solution. Success, however, has been achieved in the following way: The shell has been split as in the continuous current motor, but it acts merely as a container for the machine proper. After removal of the bolts, permitting the top half of the shell to be removed, and also the bearing caps, the bearing bushes are exposed, each provided with an eye-bolt. By applying the crane-slings to these two eye-bolts the motor is lifted out, carrying with it the stator, which is cylindrical in form. After it has been conveyed to a convenient spot the rotor can be slid out of the stator and inspection or repairs proceeded with.

There are, of course, numerous live-roll motors about the works and spare parts are provided, the motors being completely interchangeable. As an example of the thoroughness with which the details have been planned, attention may be called to the fact that the motor is designed symmetrically so that if the shaft shears at one end the whole machine can be lifted, turned through 180 deg., and bolted down again in the same place. The other end of the shaft is then available for the attachment of the half-coupling and the motor can be set running again. In this way a thoroughly reliable machine has been constructed.

The matter of enclosure deserves special attention. Often motors in steel works are exposed to atmospheric conditions, to a considerable amount of dirt and dust, and, it may be, to steam. In inviting quotations for a plant it is imperative that the steel works engineer should specify the conditions accurately, and in particular he should inform the manufacturer whether the motor is to be exposed to heat or whether it is to be put in the open air. There are many situations in steel works where high temperatures arise, but if the initial temperature is higher than the standard, the ultimate temperature may reach such a point as to destroy the installation. This has often been a source of trouble in steel works practice. Another fault has been the ordering of machines for outdoor purposes, specifying them as "totally enclosed." But a totally enclosed motor does not necessarily mean that the machine is so constructed that it will not permit the entry of moisture. Where a weather proof machine is desired the attention of the manufacturer should be very carefully called to the fact.

Controllers form one of the greatest sources of trouble in steel works plant. By the incessant making and breaking of current heavy stresses are imposed upon the fingers, and to meet the stringent conditions a large number of breaking points must be provided on the drum. Heavy tips to assist in increasing the cooling surface are essential, for the larger the cooling surface the sooner will the arc at break be extinguished. The contact fingers and tips must be renewable, and it is essential that the same facility shall be extended to all other wearing parts.

Perhaps the most striking feature of steel works electrification is the application of electrical lifting magnets, which in the last few years have been installed in surprising numbers. As an example of the economies that can be effected, one magnet has done in a day shift with one man the work that occupied three shifts of eight men in the ordinary scheme of operations. The magnets are sometimes used on jib cranes running about the yard, the crane being equipped with a small steam set generating the exciting current for the lifting magnet, sometimes on transporter cranes either in the stock-yard or against the furnaces, but more usually on overhead cranes for loading the charging boxes. The adoption of the lifting magnet has revolutionized the handling of iron and steel and has led to important increases in production and diminutions in labor costs. Incidentally, many of the cranes are now being operated by women.

In formulating a scheme for the handling of iron and steel it is not less important than in the previously mentioned instances that a thorough acquaintance with the conditions obtaining should be acquired by the engineers of both the purchasers and the manufacturers. Manufacturers who have made a study of the problem have on occasion found themselves in difficulties through the failure of the steel works engineers to realize the strenuous nature of their own work. As an example, a magnet crane for a 52-in. magnet should be a 10-ton unit, but steel works engineers have asked, "Why do you propose to install a 10-ton crane when the gross load will never be more than five tons?" The manufacturer has had in mind the fact that the crane will be working continuously, whereas in the majority of instances where cranes are installed the activity is far less pronounced than in steel works and he has realized that a 10-ton crane is essential to reliability. Instances are on record where steel works engineers have preferred to purchase lighter cranes on the basis of a closer approximation to the gross load than that offered by the more experienced manufacturer. The result has been dissatisfaction, which, unfortunately, although due to a mistaken selection on the part of the purchasers, has put magnetic handling of materials into disfavor in that particular works.

In the smaller jib cranes, where an electrical generating set and switchboard is installed, the manufacturer sometimes finds a disinclination on the part of the purchaser to pay for proper electrical gear. Such apparatus should be thoroughly weather-proof, and in addition should afford the fullest protection to the operator. Ironclad switchgear, for example, is necessary, whereas in the past the open type of apparatus being much cheaper has found its way to use.

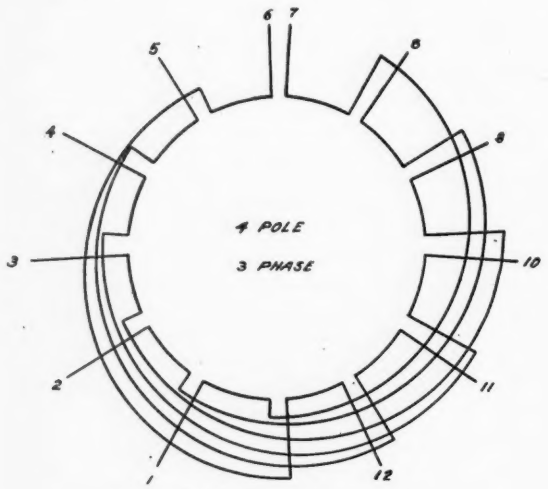
There is thus an imperative necessity for the closest co-operation between the manufacturer and the purchaser. No manufacturer should be penalized for offering plant which the purchaser deems too good for the job. Nothing is too good for steel works, and if the purchaser will bear this closely in mind in making his selection and will inquire whether the plant offered is being produced by a manufacturer thoroughly cognizant of the conditions prevailing, he is more likely to obtain a plant with that high degree of reliability and strength which is so necessary for steel works drive. It must be admitted that in the past both manufacturer and user have sometimes been guilty of negligence that has led to failure of electrical machinery in steel works. The manufacturer has been ready to take orders without making himself fully conversant with the conditions to be met, while the steel works engineer has rejected offers of a thoroughly satisfactory plant for others which had the sole advantage of lower price. Cheeseparing

does not pay in a steel works plant, and the saving of a few dollars on one machine may be followed by the loss of many thousands through reduction of output.

Multiple Connection Diagram

By Maurice M. Clement

IN these days of saving of time, material, etc., the writer has attempted to add to the list of time savers. The multiple connection diagram takes the place of four diagrams, showing connections for single star, single delta, parallel star and parallel delta; in this instance, a four-pole, three-phase diagram is shown, but the same can be done with different polarity and phasing. The following are the formulas for the different connections:



MULTIPLE CONNECTION DIAGRAM

Single Star	Parallel Delta
7, 9, 11 = line	7 and 8 = line
8, 10 and 12 = star.	9 and 10 = line
1, 4, 5, 3 and 6 in series	11 and 12 = line
Parallel Star	1, 4, 2, 5, 3 and 6 in series
4 and 7 = line	Single Delta
6 and 9 = line	7, 4, 8 and 5 = line
2 and 11 = line	2, 11, 3 and 12 = line
1, 3, 5, 8, 10 and 12 = star	1, 10, 9 and 6 = line

When connecting a stator, it is always well to look forward to the fact that some day the connections may be changed to suit other conditions, and that if the long connection is used it will be much easier to change.

By long connection is meant this: If the reader will trace out the first phase of a single star on the sketch he will see this 1 to 7 to 10 to 4; whereas, it is sometimes connected as follows: 1 to 4 to 7 to 10. By looking closely at the sketch, the reader will see that if the former method is used the connections can be changed to any of the other three much more easily than by the latter method, as half the connections do not have to be opened.

Although the short connection is perhaps a wire saver by a couple of inches, the long connection is easier to understand and makes a much neater job.

Workers Speed Up

ESTABLISHMENT of an Industrial Educational Section is announced by the Army Ordnance Department. Its purpose is to increase the productive efforts in plants engaged in manufacturing ordnance material.

The campaign includes booklets, folders, motion pictures, speakers, advertising in periodicals and exhibitions of material used by the army.

The work will be in charge of Major F. L. Thompson and Captain C. R. Dickson, with a representative in each of the eleven district ordnance offices. Those so far appointed are:

Bridgeport, Conn., Ralph P. Boaz, formerly instructor at Brown and Harvard Universities, and a writer and lecturer of note: Boston, D. D. Cassidy, architect; New York, Major J. G. Kitchell, U. S. A., formerly president Etheridge and Co., advertising agency; Philadelphia, J. W. Watson, president of the American Bronze Co.; Rochester, N. Y., William H. Gorsline, Rochester Chamber of Commerce; Pittsburgh, Charles Yon, Pittsburgh and Lake Erie R. R.; Detroit, W. G. Pipp, editor Detroit News; Cincinnati, Carl M. Jacobs, Jr., vice-mayor and former assistant city solicitor; Chicago, C. L. Benjamin, of Gray and Benjamin, advertising agents; St. Louis, Homer Hall, assistant district attorney.

These men are to be responsible in their respective sections for the activities of the Industrial Education Section which will act as a service agency at the disposal of the various district ordnance chiefs to assist them in increasing productive effort.

The boys at the front are speeding up to face death. The boys in the supporting line at home should speed up to make the death chances as small as possible.

The Engineering Department, U. S. Employment Service, 29 So. La Salle Street, Chicago, announces the following openings in essential industries and departments of the Government.

(X) A limited number of mechanical engineers, from 30 to 45 yr. of age, who are thoroughly familiar with shop and metal work; men should have university degrees and be willing to accept salary of about $2000 for highly important war work, directly with the Government, in this country. A few mechanical engineers with a knowledge of fabrics will also be considered. Engineers qualified for this work should give this notice immediate attention. The highest type of men are required for this service.

Teachers of Radio-Telegraphy, Chemical Engineers, Engineers of Tests, Transitmen and Rodmen.

Cargo and Hull Draftsmen.

One Chemical Engineer for work with an electro chemical company in Ohio.

Textile inspectors with knowledge of chemistry.

Analytical chemists for work in Ohio.

For full information and application blanks apply address given above.

Men already engaged in essential industries need apply only for position listed (X).

New Method of Cooling Gas Engines

HITHERTO the cooling of gas engines has (except in the case of very small sizes) been done by circulating water round the cylinders, and (in large engines) in the bodies of the piston and exhaust-valve. External water-cooling is the ultimate cause of most of the disadvantages under which the gas engine has hitherto labored and which have retarded its development in large sizes.

When once these difficulties, and their cause, have been clearly stated, it seems fairly obvious that they can be overcome by applying the cooling medium on the inside of the cylinder instead of to the outer surface. If water can be injected internally against the surfaces to be cooled, the heat is removed on that side of the metal on which it is generated, and therefore, there is no heat-flow through the metal and no difference of temperature between the inner and outer surfaces. The water may be distributed by means of jets, so that each part receives it in proportion to the rate at which it receives heat from the hot gases. Thus the engine can be maintained at substantially the same temperature all over, and the stresses due to unequal heating may be eliminated. A simple single-walled casting can be used for the cylinder, resulting in a great saving in weight and cost, and in improved reliability on account of the eliminating of casting stresses. The arrangements for cooling the piston, which are necessary in large engines, can be dispensed with—a point of great importance, because these arrangements, besides being costly, frequently give trouble, and their failure may easily result in wrecking the engine. Finally, pre-ignitions are entirely prevented.

In the method of internal injection, cold water is injected through a hollow casting projecting into the combustion chamber and provided with a number of holes or small nozzles about 1/32 in. in diameter. The jets so formed are comparatively coarse, so that even when projected into the flame the water reaches the part of the wall against which it is directed, but with little evaporation on the way. The jets are directed to all parts of the surface of the combustion chamber and against the face of the piston.

When Professor Hopkinson, who has undertaken much research work on gas engines, first began to consider the use of internal injection as a means of cooling, the difficulties of corrosion and lubrication seemed to be an insuperable bar, until it occurred to him that they could probably be overcome by the simple device of regulating the amount of water injected in such a way that the temperature of the whole of the engine is kept well above 100 deg. C. Under such conditions (which, of course, are only rendered possible by the absence of all external water cooling) every drop of injected water is boiled when it reaches the walls, and no liquid can accumulate. That corrosion may be completely prevented in this way has been proved by actual trials of which particulars were given.

Practical application of this system of cooling has been much facilitated by a discovery made by the author soon after he began experimenting with it. It was well known that the rate of heat flow from the gas into the metal is far more rapid at, and soon after, the moment of ignition than at any other time. It seemed likely from these experiments that for practical purposes the heat-flow into the barrel of the cylinder during the last three-fourths of the expansion stroke might be so small compared with that in the first period that direct cooling of this portion of the cylinder could be dispensed with altogether. This anticipation has been found to be correct. It is sufficient to inject water on to the surface of the combustion-chamber and the head of the piston only, the whole of the cooling of the barrel being affected by conduction into the piston, which is itself kept cool by the projection of water on to the head when it is near the center. By taking advantage of this fact, the application of water is confined to places where it can do no harm, none falling on the sliding surfaces. This is a point of some importance if the water contains much dissolved matter.

In order to put these ideas to a practical test, a Crossley engine, 11½-in. diameter by 21-in. stroke, rated at 40 b.hp. (with coal gas) at 180 r.p.m., was fitted with a new cylinder consisting of a plain barrel without any waterjacket. The valve motions were retained, and the valves and the shape of the combustion chamber were the same, the only change being the removal of all external water cooling.

Immediately after erection with the new cylinder the engine was run continuously for 120 hr. on an electrical load with coal gas. Continuous observation was kept of the gas consumption and of the load. The engine developed during this period 43 b.hp., on the average, and ran very smoothly and steadily. The average mean effective pressure was 101 lb. per sq. in. When jacketed, the engine would not develop more than 40 b.hp. continuously without overheating, and mixtures giving a mean pressure of more than 100 lb. per sq. in. produced excessive maximum pressure (over 500 lb.) with violent thumping explosions. The reduction in maximum pressures under these circumstances, by water-injection is over 100 lb. per sq. in., and the effect is very marked, the explosion becoming inaudible. The quantity of water used on this trial was on the average 102 lb. per hour, equivalent to 2.4 lb. per b.hp. hour. The temperature of the engine varied from 150 to 180 deg. C. No water was visible on the piston or the spindles of the valves, and when the engine was stopped at the end of the trial the inside of the combustion chamber was found to be perfectly dry. When the engine was jacketed and giving the same power for short periods, the jacket water removed about 67,000 B.t.u. per hour, which would be sufficient to evaporate 108 lb. of water at a temperature of 20 deg. C., under atmospheric pressure. The agreement between the available heat and the amount of water evaporated is satisfactory, such difference as there is being accounted for partly by greater radiation loss consequent on the higher temperature of the engine, and partly by the reduction in flame temperature produced by the steam, which somewhat reduces the total amount of heat passing into the walls.

The engine consumed in this trial 15 cu. ft. of Cambridge coal gas per brake horsepower hour reckoned at

atmospheric temperature and pressure. This is approximately the same as it burnt when developing the same power for short periods when jacketed. Tests at other loads have shown that with a weak mixture the gas consumption is slightly increased by the water injection, but with very strong mixtures it is a trifle less. The difference, however, does not exceed 5 per cent either way, and on the average it may be said that the economy is unaffected by the use of this method of cooling. Indicator diagrams taken in this trial compared with similar diagrams taken from the jacketed engine, show that the reduction in maximum pressure is counterbalanced by a slightly raised expansion line. The pressure is better sustained, partly by the formation of the steam and partly by the reduced loss of heat, with the result that the diagram is "fatter" and less "peaky."

After the trial just described, the engine was put to drive a dynamo in a factory engine room. Its speed was increased from 100 to 190 r.p.m. It was left in the hands of the ordinary engine-room staff for several weeks; and was worked continuously for long periods of time at excessive loads. During this time, it developed at times 50 b.hp. with coal gas for several hours together —an increase of 25 per cent on the maximum continuous load which it would carry when jacketed. Since then the engine has been taken to Cambridge, and is now engaged in regular service with a suction producer, driving the workshops and producing electric current for the engineering laboratory. It is left to itself like an ordinary gas engine, giving no trouble at all, and has now been in regular work for two years, the total time of running being 5000 hr.

Anthracite coal is used in the producer, and this coal contains a considerable proportion of sulphur. Yet there has been no trace of corrosion in the engine. The ordinary working temperature is between 120 and 200 deg. C. In order to keep the temperature between these limits, some regulation of the water supply in accordance with the load is necessary. With a throttle governor it is advisable to connect the gas supply and the water supply in such a way that the correct amount of water is delivered at all loads. In smaller engines it is important to make the whole thing automatic. For this purpose a simple form of thermostat has been designed which opens the bypass valve if the temperature falls too low.

In order to minimize the inconvenience and to guard against any danger arising from failure of the water supply, the engine is provided with a fusible plug screwed into the wall of the combustion chamber. Should the temperature rise above about 200 deg. C.—quite a safe working temperature—the plug melts, and the noise of the escaping gases warns the attendant.

From the nature of this method of cooling, it seemed almost certain that its effectiveness would be independent of the size of the engine. The truth of this anticipation has been proved by applying the method to the cooling of larger engines—one an engine of 18½ in. bore, giving 105 b.hp., the other a 1000-hp. engine of 36 in. bore. The trials of the large engine which continued for a considerable time, proved beyond any question the success of water injection, if applied in accordince with the principles enunciated. They also showed, however, as might be expected, that for ordinary commercial use the cylinder must be properly designed with a view to the employment of this method of cooling. The most obvious point is that the cylinder must be a plain barrel without any jacket.

Manipulating Hand-Fired Furnaces

RESULTS of a study made by the Bureau of Mines, Department of the Interior, to determine the process of combustion in the fuel bed of hand-fired furnaces when burning coal at such low rates of combustion as are used in house heating apparatus, are enumerated in Technical Paper 139, "Low-Rate Combustion in Fuel Beds of Hand-Fired Furnaces."

From the results of the tests conducted, it was learned that the process of combustion in the fuel bed of a house furnace is essentially the same whether firing is in small quantities at short intervals or in large quantities at long intervals. During the distillation period the percentage of combustible in the bases rising from the fuel bed is larger than it is after the volatile matter has all distilled, because during this period the fuel bed acts both as a gas producer and as a gas retort, whereas after distillation has ceased the fuel bed acts only as a gas producer. Therefore, while distillation is going on more air must be supplied over the fuel bed to burn the gases completely than after distillation has ceased. This requirement for a variable air supply over the fuel bed makes smokeless and economic burning of soft coal in hand-fired furnaces difficult.

When the air supply through the grate is completely shut off it is difficult to keep the fire going overnight, particularly when burning anthracite or coke. When it is desired to keep fire with these fuels over night, the fuel bed should be built up to at least 12 in. and a small amount of air must be admitted through the grate. With the commercial house-heating apparatus enough air to keep the fire going may leak into the ash pit when the ash-pit door is closed. Enough air to maintain combustion will not enter the fuel bed from the top surface.

As the gases rising from the fuel bed contain a large percentage of carbon monoxide (CO) it is not advisable with hot-air furnaces to close entirely the damper in the smoke pipe, if there is one, because the poisonous carbon monoxide may escape through defective joints into the air jacket and enter the rooms.

Unfortunately it is not possible to give a set of definite directions that would apply to every house heating apparatus, telling how to supply the proper amount of air through the grate and over the fire. That is something the attendant of the house heating outfit must find out for himself. With some outfits burning a given coal under certain weather conditions good results are obtained when the dampers in the ashpit door and the firing door are opened about the thickness of a match; in another outfit burning the same coal under similar conditions the dampers may have to be opened ½ in., in still another apparatus best results may be obtained with both dampers closed, enough air finding its way in through the leaks. To give enough rules so that every case would be covered, would make the rules so numerous that one would be at a loss which ones to use, and the rules would be worthless on account of their great number.

It should be borne in mind that when the dampers in the ashpit and the firing doors, as well as the doors themselves, are closed, there is some air flowing into the apparatus, because it is impossible to make and maintain an absolutely air-tight fit of the dampers, doors and joints. The quantity of air that may leak into the apparatus when the doors and the door dampers are closed varies in different apparatus.

There is, therefore, no one set of simple rules which when followed literally would insure economy in heating a house. Best economy can be obtained only after the attendant has become perfectly familiar with the furnace and its operation, and also the kind of fuel he is burning. He must have a good will to learn to run his apparatus and make an honest effort to get the best results that can possibly be obtained. He should not become discouraged if the amount of time he is giving to his furnace is entirely out of proportion to the saving of coal. After he has become perfectly familiar with all the faults and tricks of his furnace and his fuel, he will be able to get good results with comparatively little attention to the furnace. He must realize that it is distinctly up to him to get the best economy.

The following general suggestions may be found useful:

To burn the coal faster supply more air through the grate. More air can be supplied by opening the damper in the pipe leading to the chimney, by opening the damper in the ashpit door, or by shaking the ashes down from the grate. Any one of these means or all of them may be used, depending on how much faster one wishes to burn the fuel. To slow down the rate of combustion reduce the draft by partly closing the chimney damper or close the damper in the ashpit door.

To increase the supply of air over fuel bed open the damper to the chimney or the damper in the firing door or both. Air introduced over fuel bad helps in burning the gases and the visible smoke rising from the burning fuel. Too much air is as harmful to good economy as too little air.

As a general rule in house heating furnaces, a heavy fuel bed gives more satisfactory results than light fuel beds, because, during the long periods between firing a light fuel bed is apt to burn down too much, making it difficult to build a new and effective bed. When burning bituminous coal, it is better to place the fresh coal somewhat in a heap to one side of the grate and leave a small part of the burning fuel uncovered. This method of firing is found advantageous especially when the coal contains a large percentage of slack. When thus fired the coal is heated gradually and the volatile matter is distilled slowly and is given a chance to burn. Before the next firing, the coked heap of fuel should be broken and spread somewhat over the grate. A new charge is then placed on the opposite side of the furnace.

Frequency of shaking the ashes through the grate and the extent to which it should be shaken down depend entirely on how fast one wishes to burn the coal and must be determined by the attendant in each particular case. He should remember that it is the amount of air passing through the fuel bed that determines the rate of burning coal.

The fire should not be allowed to burn down too low before banking for the night, because it is apt to go out after banking. When banking the fire, it is also good policy to leave a small part of the surface of the fuel bed uncovered. This policy may avoid unpleasant explosion of the gases rising from the banked fuel.

The extent to which the dampers should be closed for banking the fire depends on the amount of air leaking into the ashpit, and must be determined in each case by the attendant. It is safer to close the damper in the ashpit door and leave the damper leading to the chimney partly opened so that there is no danger of the coal gases finding their way into the house.

The Meaning of Your Subscription to the Fourth Liberty Loan

By Ralph E. McMillin

WHAT IS THE LIBERTY LOAN?

It's forts and it's ships and it's shining guns.
  It's squadrons that sweep the sea.
It's all of the circling band of steel
  That shall keep all the home shores free.
It's grub and it's warmth for the sailor lad
  Far out on the wintry foam.
For the brave jack tar, as he fights afar,
  It's the good old "Money from home."

WHAT IS THE LIBERTY LOAN?

It's rifle and helm and it's bayonet,
  It's shovel and shard and shell
For the soldier boy in the olive drab,
  Out there on the edge of hell.
It's the soaring wings of the whirring planes
  That battle on high alone.
For the lad who is daring "Over there"
  It's the good old "Money from home."

WHAT IS THE LIBERTY LOAN?

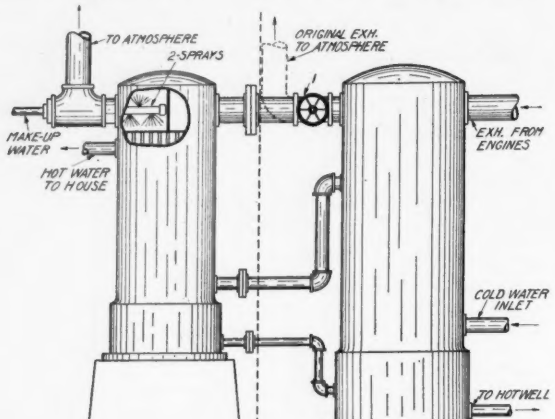
It's succor and life for a bleeding world.
  It's the glimmer of Peace at dawn.
It's the strength of a mighty arm to strike.
  It's the gleam of a great sword, drawn.
But, more than all, it's the pledge of love
  To the lads whom we call "our own."
To the boys on land, afloat, on high.
  It's the good old "Money from home."

U. S. Civil Service Commission announces an examination for assistant engineer of tests, for both men and women. Vacancies in the Navy Yard, New York, N. Y., and in positions requiring similar qualifications in any other navy yard or other naval establishment of the United States or in the Navy Department, Washington, D. C., will be filled from this examination. Salaries: Grade 1, $3.76, $4 and $4.24 a day; Grade 2, $4.48, $4.72 and $4.76 a day. Duties will consist of testing to determine the physical qualities of materials; conducting experimental tests on miscellaneous materials and devices to determine their suitability for naval uses; research work in connection with the preparation and revision of specifications for materials; and the investigation of materials submitted by various bidders. Competitors will be rated on physical ability, 10; education and experience, 90. Applicants must have reached their twentieth birthday on the date of making oath to the application. Apply for Form 1312.

Heater Installation

SOME TIME ago, I was called in by the chief engineer of a hotel plant to consult with him about his hot water problem.

The plant consisted of two 120-hp. return tubular boilers, a tandem compound engine direct connected to a 65-kw. d.c. generator and a simple engine direct connected to a 35-kw., d.c. generator. The heater was of the closed type and of a pretty good size; but though there was considerable steam going through it and out to the atmosphere, it did not supply the required quantity of hot water. It was installed as shown to the right of the dotted line in the sketch. When valve 1 was closed, the major portion of the exhaust steam went into the heating mains of the house; but if there was no heat needed, valve 1 was wide open. This arrangement would have been perfectly satisfactory if the heater capacity



METHOD OF INCREASING HOT-WATER SUPPLY

had been great enough; for during the hours that the demand for heat was greatest, the call for hot water was lightest, so that the load was fairly distributed.

After looking things over and ascertaining that the heater was clean and in good condition, I advised the installation of a similar heater of smaller capacity, connected in "tandem" with the larger one, to utilize the exhaust steam going to waste. In due time this was done, as shown at the left of dotted line, and the results were all that could be desired with one exception: we still had some steam going through to the atmosphere when there was no heat required on the house. To overcome this, I removed the ell on the exhaust outlet of the small heater and substituted a tee. I then took a piece of ½-in. pipe and cut four diagonal slots near one end, with a fine hacksaw blade. This end of the pipe was capped and a running thread cut on the other end. With suitable bushings, this was put into the heater as shown at 2. It was connected to the make-up water. When the cold water was turned on, the sprays condensed all the steam, the resulting hot water flowing by gravity through the bases of the two heaters with the other condensates to the hotwell.

This arrangement has been in service nearly 4 yr. and though there has been quite an addition to the house, it still supplies plenty of hot water. J. W. ESHNAUR.

Improving Engine Economy

M. A. SALLER'S article on the above subject, appearing in the August 1 issue, appealed to me in more ways than one, but I had thought to make no comment until reading Mr. Wakeman's article published in the Sept. 15 issue.

I cannot quite understand how Mr. Wakeman made tests, if he found no difference in the steam consumption with little or great compression and it surprises me still more that clearance seems to cut so little figure in his calculations.

Supposing the engine to be running condensing, will not closing the exhaust valve earlier to fill the extra clearance space reduce the mean effective pressure? My experience has been that the very least possible clearance means less steam consumption, even to a greater degree than Mr. Saller's example of the 14 by 15-in. Allfree engine. Incidentally, the more clearance for a required stroke the more area on which condensation can take place, and what is more wasteful than condensation in a steam plant? I must agree with Mr. Wakeman in the place to have the joint.

I always figure on leaving the break in the ring at the bottom so that the space between junk ring and cylinder will be as near nothing as possible and I also place a block at bottom of junk ring to butt snap rings on so they will remain enclosed. But if a junk ring fits properly, there will not be enough room around it at any point to allow much leakage. I have a 64-in. cylinder and the absolute clearance between ring and cylinder will not exceed 0.04 in. with a thickness gage.

Also I have several other steam cylinders, perhaps well over a dozen, and some of the pistons are even closer than the above-mentioned.

To the average engineer, 0.001 in. seems very small; but did you ever try to enter a piston or plunger in an opening that was 0.001 in. too small? Or did you ever read of the vast amount of steam that will blow through a hole one inch in length and 0.001 in. in width?

Loading the inertia governor and tightening the springs is certainly a good many times the proper medicine for a balky high speed governor.

I must go on record as suggesting that the first place to practice economy and efficiency in a steam plant is the boiler room, and as chief in a large plant I spend most of my time in the above-mentioned place.

The drop from 10 lb. evaporation from and at 212 deg. F. to 8 lb. is felt by the coal pile much more than a rise of 20 per cent in the engine steam consumption as every piece of steam machinery in the plant feels the first mentioned and only the one unit feels the last named.

In the plant where I am employed a few degrees less heat to the feed water through poor manipulation would mean the salary of two good firemen.

Let us not criticize each other too harshly, but all try to get the best possible results and tell the other fellow how we did it.

Now I will read the coal score, the feed water flow meter, and look over the pressure, temperature and vacuum dials for the day and then I'll know whether we are getting 8 or 10 lb. evaporation; whether the baffles are still holding; whether the second shift lost the vacuum again by foul screens, and a few other such incidentals.

After looking over all the records and figuring the costs, it is a genuine pleasure to look at and read Power Plant Engineering even if the clock has just struck 10 and I am due at the plant at 6 a. m. TOM THUMB.

Hiring and Holding Men

ON PAGE 762 of the Sept. 15 issue of Power Plant Engineering, there appeared an article by M. E. Duggan in connection with the subject of Hiring and Holding Men which was related to J. O. Benefiel's article of a previous issue. I would like to say that one of the worst practises in hiring a man in the power plant or in any other field of work so far as that goes is to take some one else's word for the man's qualification and then to rely solely upon it as to results expected from the man who is to do the work. Good reference is valuable, but should come from a thoroughly reliable source and that source is not generally found among the man's previous associate engineers. On the other hand, nine out of ten of his fellow engineers will not "blow him up very high" if they think that he is about to get a better job than they have and no matter how good a man he may be it is a tendency among the average engineers to have little if anything good for the man next to them who can produce the necessary qualifications to get ahead. It seems to be a sort of general disease among the average class of men. Therefore the man's "fellow engineers" will perhaps belittle the man's qualifications when they are sought for reference by an employer. It would not hurt anybody to give a man a fair chance to prove his own qualifications, whether or not he holds references from previous employers, and after a short period of observing his actual performance of duties, you can feel satisfied as to what the man is fit for.

Pull, as Mr. Duggan said, has placed many an incompetent man in a responsible position, where he was known to be absolutely unfit for the performance of his duties. On the other hand, many a good man is begrudged an opportunity by his fellow men simply because he is better than they are, and notwithstanding their knowledge of his good qualifications, they would find some cause to condemn the man in question, generally because of enviousness.

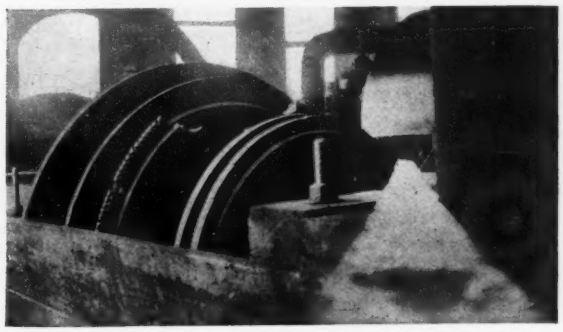
My way is to give every man a fair chance for himself and let him prove what he claims to be, as I feel that it is the honest way and the best way to deal with one another. I may add that if more of "the competent" men would give the less competent more pull in way of a helping hand towards the road to success, when the man shows an interest and good will to make something of himself, instead of closing the door in his face or taking false opinions from some one else for the man's make-up, we would all be doing something worthy of great credit to ourselves, and of no injustice to our "fellowmen."

N. EWING.

Turbine Rotor Gives Way

AT THE power plant of the United Furnace Co., Canton, O., the rotor of a 3500-kw. steam turbine recently gave way. Fortunately the casing was strong enough to hold the broken parts from flying about the building, damaging property and injuring workmen.

It will be noted in the illustration that a large section of the second stage wheel was broken out, which



VIEW OF DAMAGED TURBINE ROTOR

caused the destruction of the second and third diaphragm nozzles. The cause of the accident has not been ascertained. E. L. SYLVESTER.

Loose Connection Causes Winking Lights

IN A state institution the lights in three of the buildings were reported to the night engineer as occasionally flickering or winking. All of the wiring was looked over and found O. K. The chief engineer's house was first and the office building next on the feeder (No. 2) and both were reported all right; the next three had winking lights and the last building had no trouble. Not finding anything wrong in any three buildings the problem was about given up.

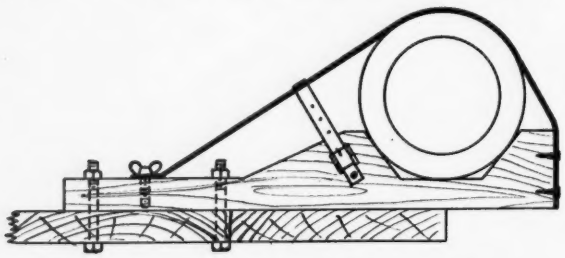
One night at about 2 a. m. the night man was tilted back in his chair when the problem of the three buildings occurred to him. A loose connection would cause lights to wink. Power house lights never wink (No. 5 switch) so connections from generator to board O. K. That's as far as he got; he jumped up and went behind the board and examined No. 2 connections from switch to feeder and found the trouble. One feeder lug was loose on No. 2 switch, so as a matter of fact all lights winked occasionally on No. 2 line. A. NEIL.

Steadying Brace for Small Windings

WHEN REPAIRING a fan or other small motor, the workman is often compelled to remove the winding of the stator from the frame so as to obtain access to remote parts. To remove those windings from the frame, the laminations must be removed with the winding; once removed, it is very difficult to work on it, as it has a tendency to roll away.

The steadying brace is a simple device, the purpose of which is to hold the winding in a steady position so that the repair man may work unhindered.

A block is cut as in the accompanying sketch and bolted to the bench. One end of a length of ribbon



CONSTRUCTION AND APPLICATION OF WINDING BRACE

copper wire about 1/16 in. thick and ½ in. wide is screwed to the end of the block and passed over the winding which sets in the cut-out portion of block; the other end of the copper ribbon is held down by means of a wing nut placed between the bolts.

A leather strap is arranged from one side of the block, over the copper ribbon, and fastened to a buckle on the other side. This is a tension strap and takes the slack out of the copper ribbon in the event of a very small winding. MAURICE CLEMENT.

Lubricant Formulas*

THE HIGHER the speed of an engine the more lubricant it needs per horsepower, and the smaller it is the more it needs per horsepower. These facts have been determined through experimentation, although one might say that the conclusions are so self-evident that experimentations in the first place should have been unnecessary. It is good science, however, to dig into the obvious, and after prying around within its depths we may learn that, after all, the subject is not so simple, that there is much to learn about it.

The quantity of oil required to lubricate a given engine may, on the surface, seem like a simple determination to make; but not so. Engines have been in operation for many years, and the majority of engineers are still ignorant on the subject of quantity of oil required. After much experimentation in a scientific way, though, it has been learned that there is a sort of mathematical application—that a given engine requires only "so much" oil per hour, depending upon its size and speed.

These experiments have been grouped and compared and recompared until the mathematical relation was derived. From the tables and rules developed the writer created the following formulas for engine lubrication:

For simple Corliss engines—Gallons of oil per hour = 0.02 hp. + 2.

For cross-compound engines—Gallons of oil per hour = 0.02 hp. + 4.

For high speed engines—Gallons of oil per hour = 0.026 hp. + 2.6.

Where hp. = horsepower.

These formulas give accurate and reliable information for stream lubrication where the oil is pumped to the engine bearings, taken back, filtered, and pumped to the bearings again, and so on. The writer is a believer in using up-to-date equipment for oiling machinery rather than the old hand oil-can method which was and is wasteful, dirty, dangerous and inefficient.

W. F. SCHAPHORST.

*Copyright 1918, by W. F. Schaphorst.

Causes of Trap Failure

THE QUESTION of a water-logged bucket, which was brought up by the article on page 727 of the Sept. 1 issue, is old, and does not mean that the cast iron has become saturated with water but that the bucket has become water-filled.

A trap bucket will fail to function under the following conditions:

A. Bearing at yoke being rough or improperly machined and fitted.

B. Cracked or porous casting not water tight, therefore lacking in buoyancy.

C. Rough casting with protrusions which bind on side of body casting.

D. Heavy sand or foreign matter accumulation overcoming buoyancy.

E. Trap hooked up backward inlet to outlet connection, etc.

A may generally be overcome by filing and adjusting after a careful examination of the cause of trouble and may be checked when assembled by tying a string around the bucket and leading out through the vent cock hole in the cover, thus raising or lowering the bucket through its normal travel.

B may be remedied by drying out in a hot fire and giving two coats of Smooth-On mixed to the consistency of a stiff grout. To lighten the bucket, the upper edge can be filed thin back a distance of 2 in.

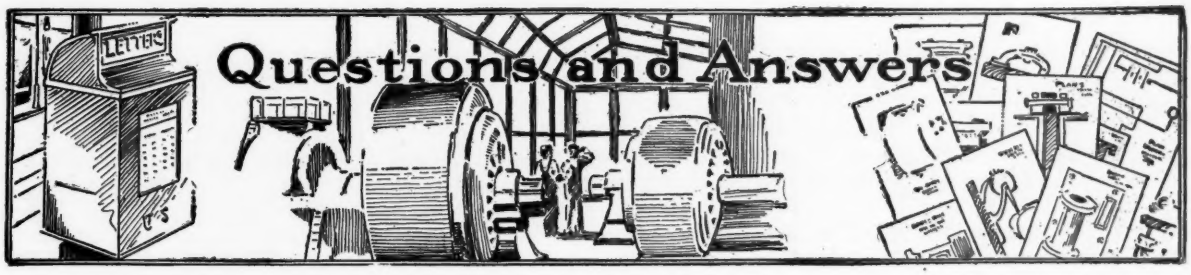
C can be overcome by filing, and probably would be helped by bearing adjustment as in "A."

D. Accumulations of foreign matter most frequently are the cause of trouble in bucket traps and this type of trap should not be used where there is solid matter on a steam pressure in excess of 60 lb., a float type trap with blowoff connection being the logical outcome of required trap service and one with which you can get 2 yr. service guaranteed. THEO. HAIGHT.

RECORDS of the U. S. Shipping Board show that there are now over 386,000 employes in the shipyards, as against 50,000 in July, 1916. More than 2,000,000 dead weight tons of shipping have been completed and delivered to the board during the past year.

TO GET a good glazed air-tight bottom for oil burner furnaces, throw in a bunch of old glass bottles. These will melt and cover the bottom and plug up all holes.

BACK YOUR OWN with the bond you own.



Firing Down-Draft Furnaces

IN THE Questions and Answers section of the June 15 issue is a communication on the subject of down draft furnaces that is somewhat misleading.

The first or descriptive paragraph is fairly, though not entirely, correct. The lower grate is not "fed by the half consumed fuel falling from the upper grate." The sole object of the lower grate is to catch what unburnt fuel falls from the upper grate in stoking. In many plants it could be dispensed with entirely.

The second paragraph is wrong. The bed of fuel on the upper tubes is not all green coal; in fact, only a small part of the fuel bed is green coal. It lies in strata, first black coal, then orange coke, then on the water tubes, a layer of extremely white incandescent coke, the heat from it being communicated directly to the small streams of water contained in the tube. The grate area is *not* "relatively small" but, if the furnace is properly designed and constructed, will be found more correct and better suited to the needs of the boiler than the usual grate allowance of the boiler manufacturer. A strong draft is required to draw the distilled gases through the body of fuel, and to make a proper mixture of gas and air, thus intensifying the temperature and completing combustion. A Bunsen burner must have a certain amount of air for complete combustion. A down-draft furnace is a Bunsen burner on a slightly different scale.

Paragraph three is also wrong. More efficiency is obtained by the use of fine coal, provided it is mixed with sufficient water to thoroughly wet it. When the coal is fired on upper grate, it quickly cokes and it takes considerable effort to work it between the staggered tubes or cause any amount to fall on the lower grate. A properly designed down draft furnace should burn 95 per cent of the fuel on the upper grate.

Paragraph four speaks of fire tile. This part is correct for water-tube boilers, but what was stated about overload capacity is wrong. We do not use tiling on return tubular boilers, yet we have many equipped with the down draft, doing from two to three hundred per cent of rating and passed by the local Fuel Administrator's inspector as being highly efficient.

The first part of paragraph 5 is right, but not the latter part. The coal is *not* "expected to drop through the grates upon the second grate," neither is combustion completed on the second grate, for the reason that a *good* down draft fireman will burn almost *all* combustible matter on the upper grates. What little falls through should be 95 per cent consumed before it leaves the upper grate.

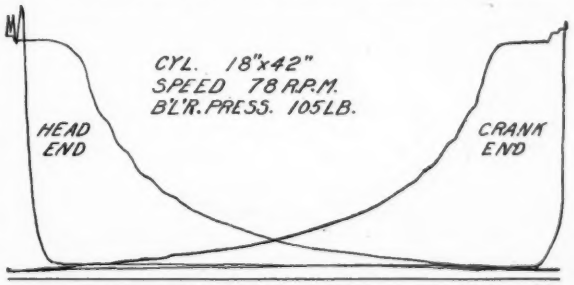
The only part of paragraphs 6, 7, 8 and 9 that is correct is the last statement in the ninth paragraph that "a great deal depends upon the assistance of the fireman," and this same applies to any other device made for burning coal, whether stoker or flat grates.

FRANK R. SMALL.

[It would undoubtedly be very interesting for the readers of Power Plant Engineering to learn more regarding the use of down draft furnaces. If, therefore, you have had any experience with this type of furnace let us hear from you, stating just what you have done and what you have encountered along this line. How have you handled down draft furnaces and what have been the results?—Editor.]

Setting Valves After Repair

WE RECENTLY installed a new high pressure cylinder to our cross-compound Allis Corliss engine and after placing the rocker in its central position I set the valves by the marks on the cylinder and also set the eccentric on the factory mark. The enclosed indicator cards show



CARDS TAKEN FROM REPAIRED ENGINE REDUCED TO 3/4 ORIGINAL SIZE

the results. The engine runs fairly well, but I can not understand what further must be done to get a better card.

Will you please analyze the cards and tell me what changes must be made to produce the best results? I used a 50-lb. spring in taking these cards. E. A. F.

A. The difficulty with your engine is, that admission is too early on both ends, but considerably more so on the head end than on the crank end. Other events in the stroke seem to be about right, although it may be possible that when you get the admission line straightened out, you will find that compression is rather early.

To get the admission later, you should lengthen the links from the wristplate to the valve crank, and it is probable that this will necessitate a slight readjustment of the dashpot rods. Be careful, in lengthening these admission valve links, that you do not get them so long that the hooks will jam against the catch plates on the valve crank.

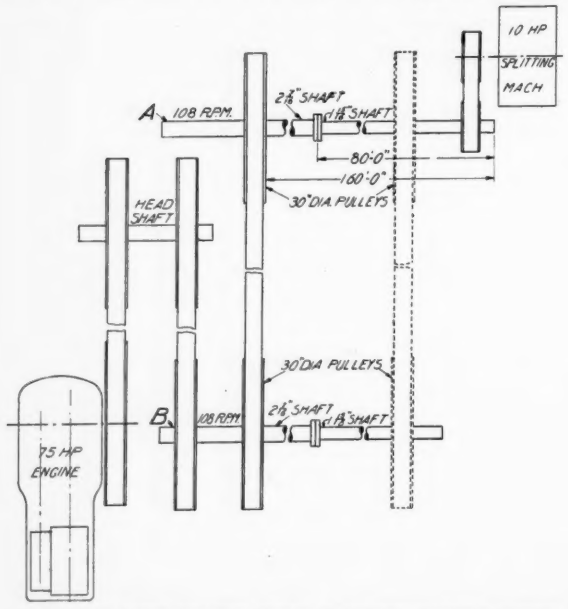
It is probable, also, that in order to bring the admission more nearly equal on the two ends, you will have to lengthen the reach rod between the rocker arm and the wristplate, so that the wristplate swings a little farther towards the head end of the cylinder than would be indicated by the marks on the wristplate hub.

In case you cannot get adjustment enough to bring the admission back where it belongs by this method, you will have to set the eccentric back a little on the shaft in order to bring the admission later, and then shorten the exhaust valve links which reach from the wristplate to the exhaust valve cranks, thus bringing exhaust a little earlier and compression a little later.

There have been so many different designs of Allis-Chalmers valve gears, that it is difficult for us to give you more than these general directions, but we believe these will guide you in the course to follow. The only caution is, make all changes a little at a time and watch results carefully, both on the operation of your valve gear and the effect on the card.

Double Belt Drive for Vibrating Shaft

ENCLOSED please find sketch showing a diagram of our weave room drive. What is shown dotted on the sketch, indicates what we intend to apply; that is, a second belt to drive one of the line shafts. At the end of line shaft A, you will find indicated a splitting machine which takes 10 hp. to drive it. As soon as we throw on this machine, the speed will slow down considerably, the governor not taking care of it, this on account of the light load we are carrying which is only 15 hp. for all our looms together (the engine is 75 hp.).



PARALLEL LINE SHAFTS WITH PROPOSED DOUBLE DRIVE

The latest indicator diagram showed only 1/10 cut-off. As soon as the splitting machine is thrown off, the speed gains quite considerably, and in every case the engineer has to regulate the governor by putting weight on or taking it off.

On account of shaft A being so long, and only 1 15/16 in. in diameter on the end for 80 ft., we imagine that there is quite considerable torsion, and we thought we could overcome this by putting another, that is, a twin drive on, which would steady the shaft in question. F. M.

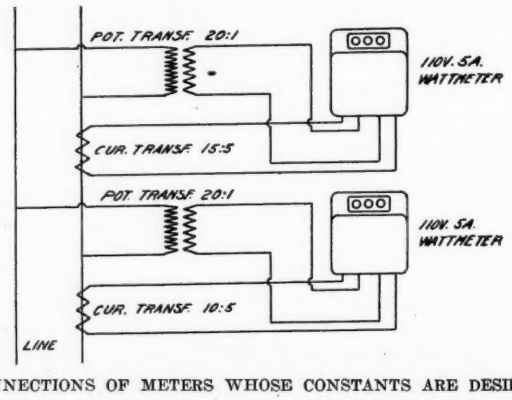
A. It hardly seems possible that the change you propose would cause any better speed regulation of your engine. There may, however, be some vibration in the torsion of your line-shaft, which would cause some trouble in the operation of your splitting machine, since by reference to handbooks we find that a shaft 1 15/16 in. in diameter, running at 100 r.p.m., should not carry more than 8-hp. load, and undoubtedly you would get rid of some of this vibration by installing the extra belt drive, as you suggest.

The variation in speed of the engine, however, should be taken up directly with the manufacturers of the engine, as they undoubtedly can suggest some means of remedying this difficulty.

Determining Meter Constants

WHAT CONSTANT must we multiply the meter readings by (see sketch) to get the correct energy output? How can we get these constants, or how are they figured out on these or any other meter?

How do you figure the constant on a meter that is taken off from 2300-v. 60 to 5-amp. circuit and put on to a 110-v. 5-amp. house circuit? J. A. P.



CONNECTIONS OF METERS WHOSE CONSTANTS ARE DESIRED

A. In the diagram of connections sent us, we note that you have two watt-hour meters connected to a single phase line. Both of these meters, as you state, are common 110-v. 5-amp. house meters—one of which is connected to the line through a 20 to 1 potential transformer and 15 to 5 current transformer, while the other is connected to the line through a 20 to 1 potential transformer and a 10 to 5 current transformer.

These meters, as you state, are 110-v., 5-amp. instruments, and as a consequence, if they were connected to such a 110-v. line, they would indicate directly the amount of energy being measured. There is, however, a transformation of 20 to 1 in the case of your voltage, and another transformation of 15 to 5, or 3 to 1, in the case of your current; so that for every kilowatt indictated by your wattmeter, there are 20 times 3 or 60 kw. passed over your system; so that it will be necessary to multiply all your meter readings, in the case of this meter, by 60 to obtain the true number of watts or kilowatts, as the case may be.

With the other meter, however, we note that you are using a current transformer having a ratio of 10 to 5, or 2 to 1. This would require, instead of a constant of 60, a constant of 20 times 2 or 40, thus necessitating multiplying the readings of this instrument by 40.

Undoubtedly the meter referred to in your second question was primarily designed and constructed for use on a 2300-v. 60-amp. circuit. If such is the case. the meter, while not actually measuring the energy passing through the circuit, at least indicates the actual amount of energy passing through the circuit.

If, therefore, you intend to use this meter on a 110-v., 5-amp. circuit, it will be necessary to make corrections accordingly. The voltage transformation in this case is again 20 to 1, while your current transformation is 12 to 1. It will, therefore, be necessary, in order to obtain the correct reading, to multiply your wattmeter reading by 1/240.

Horsepower Unit Derivation

How WAS the horsepower, or 33,000 ft.-lb. of work per minute, established as a unit for measuring the power of an engine?

2. How did they derive the heating surface of a boiler?

How do you calculate the heating surface of a B. & W. boiler?

3. What is an induction heater?

4. How do you calculate the size of a boiler feed pump?

5. How do you calculate the size of a spring loaded safety valve by the Massachusetts formula? F. P.

ANSWERS

THE HORSEPOWER as a unit for measuring the power of an engine was established by James Watt, at the time when he was making his improvements on the steam engine. It was supposed to be the rate at which a horse could do work if working continuously. As a matter of fact, it was more a guess than anything else, but has become so firmly established that it is now universally used as a unit.

2. To compute the heating surface of a boiler, we figure the external surface of all the tubes in the boiler, plus half the surface of the shell of the boiler, plus the area of the back head, and minus the area of the ends of the tubes which enter the tube head. The thought is to figure the surface of all parts of the boiler which have water on one side and hot gases on the other; the surface being taken as that which is next to the water. By this method, the heating surface of a B. & W. boiler is the inside surface of the tubes plus half the surface of the steam drum.

3. An induction heater is one in which the current of exhaust steam flows in parallel to the current of feed water—generally through a nozzle in the center of the water inlet. In this way, the force of the current of steam going in tends to draw the water with it and mingles with the water, thus causing the steam to be condensed quickly.

4. To find the size of pump for a boiler, we take the rated horsepower of the boiler, and figure that each horsepower will require 30 lb. of water to be delivered per hour, or practically 4 gal. per hour. In figuring the size of pump, it is usually calculated for double the rated capacity of the boiler, in order to allow for slow running and for forcing the boiler.

5. The Massachusetts formula for the safety valve, as you have given it, means that we have to determine what rate of firing is to be used; that is, the pounds of coal to be burned per square foot of grate surface. We will suppose that this is 30 lb. Then we figure the water evaporated per pound of coal, which might be 9 lb. This would mean that 270 lb. of water would be evaporated per square foot of grate surface per hour, or 0.075 lb. per second, which is the value W in the formula. P is the pressure, in pounds per square inch, absolute; that is, the boiler pressure plus 15 lb., for practical purposes.

Assume that the boiler is to operate at 150 lb. pressure. The absolute pressure would be 165, and we should have,

$$A = \frac{0.075 \times 70 \times 11}{165}$$

which will work out, approximately, to 0.35 sq. in. safety valve area per square foot of grate surface.

If you have, therefore, 20 sq. ft. of grate surface, your safety valve area provided must be 20 times 0.35 or 7 sq. in., which for the beveled seat safety valve would be a 3-in. valve. This at 150 lb. pressure will take care of about 30 sq. ft. of grate rather than 20. This is, however, on the basis of a low coal combustion; considerably lower than that which we have assumed in the problem.

What is CO_2?

WHAT IS MEANT by CO_2 gas? Kindly define.

W. W. S.

A. CO_2 is the chemical abbreviation for carbon dioxide. It is the gas formed by the union of one atom of carbon and two atoms of oxygen during combustion, and is the result of a complete combustion of the fuel; that is, the carbon has taken all the oxygen it can accommodate.

Incomplete combustion is indicated by the presence of CO, or carbon monoxide, where each atom of carbon has combined with only one atom of oxygen.

The objection is, that the burning of a pound of carbon to CO gives off only about 4500 heat units, while the burning of a pound of carbon to CO_2 gives off 14,000 heat units. It is essential, therefore, that there should be such a supply of oxygen and such a mixture of it with the gases from the fuel, that complete combustion will be secured.

For ordinary boiler gases, the percentage of CO_2 at the stack should be from 12 to 18. The balance will be nitrogen and excess oxygen, which always has to be supplied in order to get complete combustion.

FOR ARTILLERY, automatic rifles, and small arms, and for ammunition for them, we have spent over $3,700,000,000.

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CONTENTS

The Millers Ford Station. Illustrated....825
New Essington Works Exceed Schedule by 40 Per Cent..831
Using Exhaust Steam. By S. E. Balcome. Illustrated....832
Economical Engine Operation. By Martin O'Connor. Illustrated....835
Smokeless Combustion with Chain Grates. By T. A. Marsh....835
Fuel Economy in Hand-Fired Power Plants—II. Illustrated....837
Improving Factory Steam Plants—IV. By H. A. Wilcox. Illustrated....840
Service Restoring Relay System. Illustrated....845
Electrical Plant in Steel Works. By Mark Meredith....846
Multiple Connection Diagram. By Maurice M. Clement. Illustrated....848
Workers Speed Up....848
New Method of Cooling Gas Engines....849
Manipulating Hand-Fired Furnaces....850
Letters Direct from the Plant: Heater Installation. Improving Engine Economy. Hiring and Holding Men. Turbine Rotor Gives Way. Loose Connection Causes Winking Lights. Steadying Brace for Small Windings. Lubricant Formulas. Causes of Trap Failure. Illustrated....852
Questions and Answers: Firing Down-Draft Furnaces. Setting Valves After Repair. Double Belt Drive for Vibrating Shaft. Determining Meter Constants. Horsepower Unit Derivation. What Is CO_2? Illustrated....855
Editorial: Order Repairs Early. Interconnection of Isolated Plants....858
Light, Portable Coal Conveyors. Illustrated....860
A New Type of Oil Line Pump....861
Remote Control Induction Motor Starter. Illustrated....862
Practical Reference Tables: Cubic Feet of Ammonia Vapor to be Circulated per Minute per Ton of Refrigeration. Apparent Volumetric Efficiency of Ammonia Compressors with Various Clearances and Compression Ratios. Freezing Points for Alcohol and Water Solutions. Chart for Calculating Pipe Offsets. Standard Fire Brick Dimension....863
Flywheel Explosion Kills Attendant.. Illustrated....865
Electrical and Mechanical Engineer Wanted....865
William Kent....866
Catalog Notes....866
Trade Notes....866

A Subscription Swindler

Attention of readers is called to the fact that the subscription price of Power Plant Engineering, at present, is $1.50 a year; that Power Plant Engineering has never, under any circumstances, offered a yearly subscription at less than the regular price, and that no premiums or gifts are offered with a year's subscription.

The reason for this notice is, that a subscription swindler, who has called himself at various times by the name of "Carlton," "Carlson," "Clifford," and more recently "Daniels," has been offering to engineers in New York City and vicinity subscriptions at less than regular rates, and premiums of various kinds with one year's subscription.

This swindler has no authority from Power Plant Engineering and the only way that we hear of his work is through complants, received several weeks after he has swindled an engineer, calling attention to the offers that he has made. He is described as smooth-shaven, 5 ft. 7 or 8 in. in height, of slight build, with a round face, light hair, blue eyes. He has at times worn a soft hat and blue suit, with a brown Raglan overcoat, and more recently has been wearing a straw hat and tan-colored suit.

He carries a copy of Power Plant Engineering, and sometimes of the Power Plant Engineering Library, which he has secured in some fashion. He boasts of his connection with the Chicago office, is well informed on engineering matters, and speaks of his knowledge of the former publishers of the "Isolated Plant," and of acquaintance with the New York police force. He carries no credentials from Power Plant Engineering, and gives receipts on a leaf taken from an ordinary merchandise receipt book.

All accredited agents of Power Plant Engineering carry written credentials, signed by the Editor, Arthur L. Rice, and also carry receipt books, in regular form, bearing the trade-mark on the receipt, Power Plant Engineering, as printed at the top of the pages of the journal.

This swindler has a long list of charges against him, and we shall be glad to pay a substantial reward to any engineer who assists in arresting him and turning him over to the police department. We shall appreciate any evidence in regard to him or his operations, either by mail to Power Plant Engineering, 150 Nassau St., New York City, or by telephone to Beekman 4338.

As a protective measure to engineers, please warn all your acquaintances in regard to this swindler, and if he enters any engine room seeking subscriptions to Power Plant Engineering, detain him, send for the police and turn him over to them; then call our New York office and give them the details in regard to the matter. Our New York representative will attend to prosecuting him.

Order Repairs Early

Reconstruction work is ordinarily done during the summer when the demand for power is slackened. This year government requirements have kept most power plants running at top notch, and reconstruction has waited in vain for a chance to take machinery out of

commission. This means that plants will have to be repaired, and rebuilt where necessary, "on the fly," so that no stoppage can be allowed to wait for new parts or material.

This work will include replacements on engines, boilers, furnaces, stokers, grates, pumps, etc., and not only parts for immediate replacement should be ordered, but, in view of the fact that plants will be required to run at high speed, continuously this winter, such parts as are likely to be needed for emergency repairs.

The fore-handed engineer does this in ordinary times. The man who does not have the proper foresight is likely to wait until some piece of equipment breaks down, then telegraph madly to the manufacturer for repairs, "to be shipped at once by express." In ordinary times, the manufacturer meets this condition by a "rush" shop order, which, of course, curtails extra expense, and the purchaser pays the cost of his procrastination. He runs crippled until the repair parts come, pays express, telegraph and rush order expense, and is lucky to get off without mistakes that are always likely to accompany rush work.

With the conditions of last winter, which will probably be duplicated this winter, there will be no such thing as rush shipments. Shops are loaded with government orders, many of them with "priority" tags that cannot be side-tracked for repair work. Express shipment is slow and rulings forbid large shipments. Only those plants engaged in making vital government necessities will be able to get any accommodation in making or shipping of repairs. The central station and electric railway plant, while essential to the convenience of the public, are not on the priority list, hence they need to be especially forehanded in getting material that is or may be needed to maintain operation.

Purchasing agents do not, as a rule, concern themselves with delivery of repair parts needed for future work. It is "up to" the power plant engineer and executive to see that orders are placed early and followed up until delivery is made. Only in this way can the man who is responsible for keeping the wheels turning and his plant in the best possible condition to make every pound of coal produce its full bit in finished product to aid the cause of liberty, be safe against delays and shut-downs that may do great harm.

Interconnection of Isolated Plants

Fuel conservation and the more efficient use of machinery are being widely sought today by central stations through interconnection of lines. Less is heard about the possibility of extending this good work to the field of the isolated plant, but it certainly deserves consideration. To bring about such an interconnection, it is likely that in a good many cases there will have to be a lifting of restrictions bearing upon the running of temporary conductors across streets and alleys, excavation permits, and the purchase of cable and other supplies by civilian buyers. None of these obstacles appears insurmountable, once the military justification of an interconnection plan is made clear.

Take the case of two plants located in adjacent office buildings or in two mills in the same neighborhood. The importance of saving fuel and supplies and of utilizing reserve capacity to the utmost extent consistent with reliable service need little argument. Every pound of coal wasted helps the enemy by that much, and cost is a secondary issue in the face of the war demands upon the natural resources of this country. As for generating machinery, the enormous output being produced at the factories on behalf of the army, navy and merchant marine, to say nothing of public utility orders, has thrown generator deliveries into the dim and distant future no less than prime mover shipments. It is pre-eminently time to make the utmost use of existing facilities. Hence the engineers and owners of adjacent plants will do well to study the possibilities of interconnection as a local problem, and then extend the field of analysis to outside power supplying agencies.

Probably as good a way as any in which to go about such a task is for the chief engineers of the adjacent isolated plants to have a conference at which each will bring full data as to equipment ratings, loads, fuel consumption, water supply, labor requirements, and machinery characteristics. Then let them ascertain wherein the loads cease to overlap and combine the output curves of the two or more stations concerned into a total output curve, so that the opportunities for cutting down idle capacity may be seen. Estimates can then be prepared as to the cost of the necessary tie line installation, including in some cases transformers to bring the interconnection voltage up to an economical plane of transmission, or in another case, perhaps, to enable the facilities of one plant to be utilized in another run at a lower or higher electrical pressure.

The heating problem will naturally be closely concerned in many interconnection schemes involving isolated plants. Careful study will be necessary to determine whether in a given combination of plant facilities heating shall be done locally through exhaust steam chiefly or whether the use of low-pressure steam obtained through a reducing valve should be encouraged. A thorough study of interconnection even between two adjacent plants is likely to require consideration of several different operating programs, and it may be desirable in some cases to call an outside engineer into the conference to give the benefit of his own experience in interconnection to the conferees. There is no place here for either professional jealousy or for industrial feudalism.

The problem of working out an effective interconnection plan, even between two plants on opposite sides of a single alley, cannot satisfactorily be thrashed out and a solution applied in an off-hand manner, and in many cases several conferences will be necessary to establish a satisfactory working basis. Here and there, very likely, no saving worth while will result from tying two plants together, but in many cases the diversity of the loads will yield fruit if the plants are articulated skilfully. This is no time in which to attempt to drive sharp bargains relative to the interchange of energy and the purchase of steam for heating; a fair price is naturally sought and expected by all parties concerned, but more than this is likely to stand in the way of the early co-operation of plants which should be encouraged as a war measure where it can be done with desirable fuel savings, economy of labor and more efficient utilization of plant capacity.

Light, Portable Coal Conveyors

NOWHERE in the industrial fabric has the disturbance brought on by war conditions been more keenly felt than in the unskilled labor market—among the shovelers, lifters and movers of goods and materials. Perhaps because this type of labor had always been plentiful and relatively cheap there had been, before the war, less application of machinery to such purposes than in almost any other field.

Ore docks, coal docks, grain elevators, and some large plants were equipped with complete and well arranged conveyor systems. But unless large quantities of material were handled in a highly organized way, it was the custom to depend on human labor using very primitive equipment.

FIG. 1. PORTABLE BELT CONVEYORS USED IN LOADING COKE CARS BY THE WESTERN UNITED GAS AND ELECTRIC CO.

War conditions undermined old methods from two directions. Transportation became uncertain and made it essential to receive material in the largest possible quantities whenever transportation was available and store it until it could be used. It was no longer possible to depend on shipments arriving at the plant in such regular sequence that coal or other materials could be unloaded from the cars for immediate use.

Storage required more handling, more labor. This increased demand for labor came at a time when the ranks of labor had been greatly depleted by the war demands for man-power, and when all industry was straining to the utmost to produce war materials.

This situation aroused more interest in light, portable material-handling machines than ever had been felt before. It became an established principle with many companies not only to replace labor by machinery whenever the machine could do the work cheaper, but to prefer the machine if the costs were the same or even slightly higher.

Conveyors were designed and built in standardized sections that could be assembled in units of any length to meet any requirements. This made it practical to carry at factory for prompt shipments a large stock—and held down the investment tied up in such a stock to reasonable proportions.

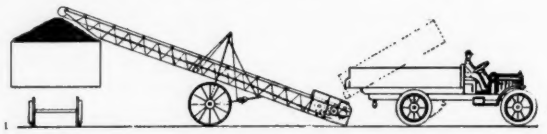


FIG. 2. CONVEYOR USED TO LOAD RAILROAD CAR FROM MOTOR TRUCK

These conveyors in hundreds of businesses have proved their ability to reduce handling costs from 50 to 90 per cent. Single units have replaced from 3 to 20 men. They were so badly needed that they have paid for themselves, in many cases, in less than a month.

Such portable belt conveyors elevate as well as move material and so have made it possible to use more fully the storage space available. Without additional cost coal can be piled to the top of a coal shed, and on the open

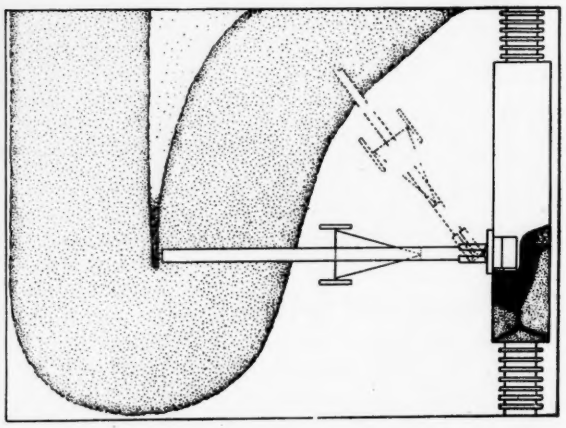


FIG. 3. CONVEYOR USED TO PILE HIGH OVER WHOLE AREA

ground, higher and more compact piling is possible. Additional construction of storage buildings can in this way often be avoided.

In the service of the Western United Gas & Electric Co. at its plant in Joliet, Ill., two portable belt conveyors made by the Barber-Greene Co. of Aurora, Ill., are operated in series in loading coke into railway cars. These cars are loaded in from 2 to 7 hr., according to size and type, with less than half the labor that was

previously required to load them in from 7 to 10 hr. The saving in cost is about 50 per cent. This is typical of results secured by use of these conveyors in many places.

Several types of conveyors have been worked out to meet different requirements by the Barber-Greene Co. For elevating at angles under 25 deg. a plain belt is employed. For angles of 30 to 35 deg. a belt equipped with steel flights is provided to prevent the material slipping down the grade. The conveyors are made portable by mounting them on a wheeled truck or suspending them from a trolley attached to an overhead steel cable.

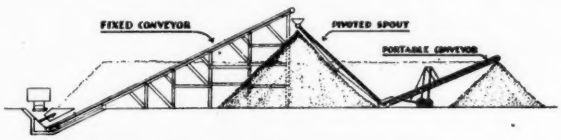


FIG. 4. PERMANENT CONVEYOR, A CHUTE AND PORTABLE CONVEYOR FOR BUILDING STORAGE PILES WELL BACK FROM THE RAILROAD TRACK

A wide variety of applications have been worked out since these conveyors went into use—many of them unforeseen until they were discovered in practical use. They unload cars into piles, into storage sheds, into wagons or motor trucks. They load cars from trucks or wagons, storage piles or sheds. Where the carry is longer two or more conveyors can be worked in combination—sometimes with a chute between them.

A careful study has been made of piling systems and methods developed by which the largest tonnage can be stored on a given amount of surface. A few methods of applying the conveyor are illustrated in the accompanying drawings.

A New Type of Oil Line Pump

OUT OF the necessities of war have developed many improvements in machines and methods which are adaptable in the industries of times of peace. There seems little relation between the hydraulic forging of shells and the pumping of oil, yet from the requirements of one have led developments proving greatly advantageous to the other. Before the war, pumps furnishing supply to hydraulic presses were usually built with cast iron or bronze water ends, except for very high pressures. For pressures of 5000 lb. per sq. in. and above, cylinders were hammered out of forged steel and were limited to very small sizes. The last 3 yr. has seen a wonderful development in this work. Sizes have increased and designs simplified and the forged cylinder has come into use for all pressures above 1000 lb. per sq. in. The Worthington Pump and Machinery Corporation engineers were the first to recognize the possibilities of this construction for oil line work where the pressures run from 700 to 1000 lb. Their first suggestion of its use for this service was not well received by the operators, for it involved a radical change from the pot valve casting construction with which they were thoroughly familiar. After considerable effort, however, some sacrifice in price, and making of rigid guarantees, a number of trial installations were secured. The success of these trial pumps has so conclusively demonstrated their value that this form of construction will probably eventually become the standard. It is now used on pumps from 4 by 12 duplex, 4000 bbl. per day up to 6½ by 24 duplex 20,000 bbl. per day and can be furnished for larger capacities if desired.

There are a number of features in this construction which appeal to the operators. Broken cylinders and valve pots are entirely eliminated for the single steel forged billet in which cylinder and valve chambers are incorporated, has such an excessive strength that breakage under pressure is impossible. The use of gaskets on the pressure joints is not required for the points are of small size and special form, which permits making them absolutely tight metal to metal. Heavy valve pot covers do not have to be lifted to get at the valves. Each valve has its individual cover in the form of a screwed plug easily handled. There are no studs to break off in making up pressure joints when handled by rough inexperienced labor. Every part of the pump is readily accessible to a man standing on the floor. It is built low down, close to the foundation, by which it is rigidly supported.

Valves are solid bronze balls, or bronze wing guided type with or without leather face, according to requirements of service. While all of the valves are accessible from the top of the cylinders the suction valves are located below the plungers and the discharge valves above plungers. This allows a reasonably direct flow through the pump without the abrupt reversal of direction, such as occurs in the pot valve type of construction. The location of valves permits of a minimum size pulsation chamber, thus reducing the clearance. This is a highly important feature in handling volatile fluids. A further advantage due to location of valves is a reduction of several feet in the suction lift, thus allowing supply tanks to be drawn down lower.

The excellent vacuum which this pump can maintain permits its use as a suction pump for drawing oil out of the pipe lines in case of necessity.

While the essentially new feature of this pump is the forged steel oil end construction, yet the power end is also worthy of attention, for it is designed with a view to meeting the hardest continuous service. Heavy frames supported throughout their whole length directly on the foundation give great strength and rigidity. All bearings and pins are of very liberal size and are provided with readily taken up adjustments. Gearing of either the spur or herringbone type is made of suitable ratio for direct connection to oil engine.

There are a considerable number of these pumps in service in the mid-continent field and operators familiar with their service are very enthusiastic about them.

NO COUNTRY, no people, can be truly great as the result of individual achievement. We must keep step with, and attune our ears to the music of the march of the human race, for while monarchies and republics have risen and fallen, the human race has pressed on to better things. The struggle upward has been at times a difficult one; human suffering, blood, misery and brutality have marked the way. If all the cries of dying men, agonized women and suffering children that the passing ages have heard, could be rolled up into one wave, that sound of agony would stifle the roar of all the combined guns that surge along the western front.—EUGENE MCAULIFFE.

Remote Control Induction Motor Starter

THERE HAS always been a demand for a device for starting small induction motors from remote points by throwing them directly across the line.

The General Electric Co. has recently developed and placed upon the market such a starter, known as the

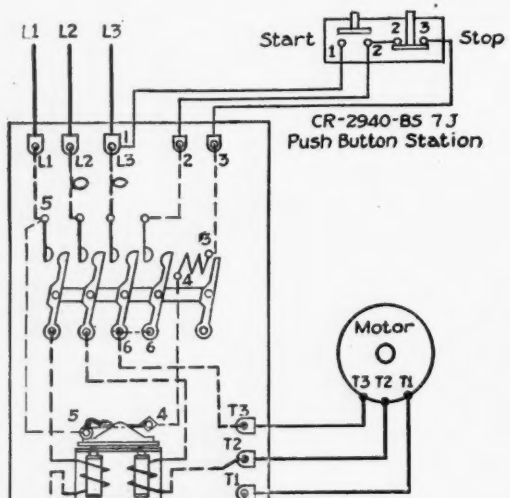


FIG. 1. CONNECTIONS OF CR 7006-A1 REMOTE CONTROL SWITCH

CR-7006 Remote Control Switch, arranged for push button control. This starter is applicable for use with motors up to and including 5-hp., 110-v. and 7½-hp., 220, 440 and 550-v. In addition to its starting function

FIG. 2. CR 7006-A1 REMOTE CONTROL STARTER

it provides protection against under voltage and overload.

The device consists of a 25-amp., 3-pole contactor with two inverse time limit gravity reset overload relays mounted on a slate base totally enclosed in a strong sheet iron case.

A small "start and stop" push button station is used as a remote control switch. Completion of the starting circuit, by pressing the "start" button energizes the coil of the magnetically operated switch, closing the contacts, which throw the motor directly on the line. Interruption of the circuit or a radial decrease in voltage permits the contacts to reopen by gravity, thus stopping the motor which cannot start again until the "start" button is pressed.

The overload relays can be adjusted for various values ranging from normal up to 50 per cent above normal. They can also be adjusted over a wide range

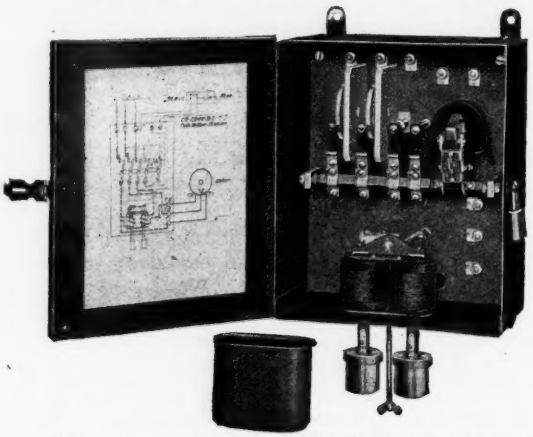


FIG. 3. INTERIOR VIEW CR 7006-A1 REMOTE CONTROL STARTER

of time values. The relay trips automatically and resets by gravity.

The cover of the enclosing case is furnished with a hasp so that if desired it can be locked in a closed position by padlock.

IN READING the reports of allied successes, we are likely to lose sight of what the forces of Italy are doing. Last June, Austria attempted to drive the Italian army back and capture Venice. The result is history. The Huns were thrown back across the Piave River with tremendous losses; the Italians drove them into the mountains, and are still driving them.

In the attack on Rheims, Italians were guarding that front, flanked by French, British and Americans.

German war lords ordered a drive by the Turk-Bulgar-Austrian combination through Albania; but again the sons of Italy stopped the onslaught and drove back the enemy.

Thousands of Italian soldiers are fighting in Picardy, in Palestine, in Macedonia. In our admiration for the work of our allies, high praise should be accorded to the part that Italy and her sons are playing.

IN STEEL reinforced concrete design, the area required is computed on the assumption that the steel will carry all the tension and the value of the concrete in tension below the neutral axis is neglected.

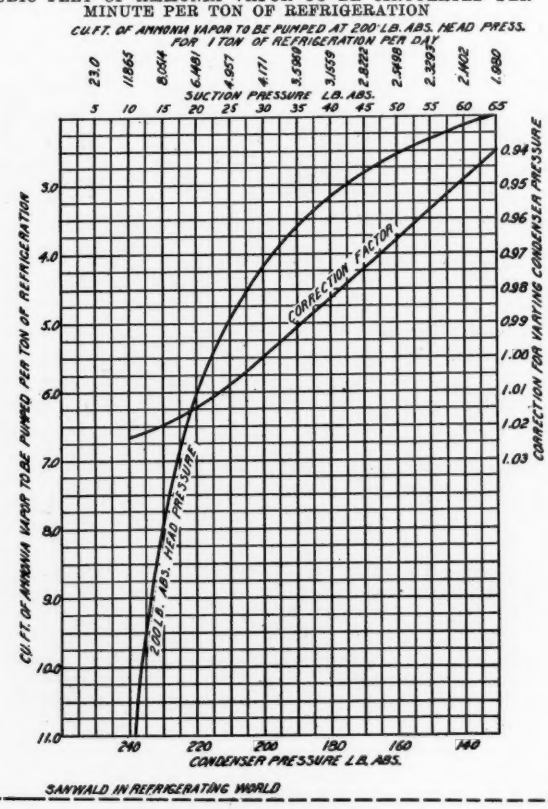
BACK THE fighting men with the fighting loan.

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps.

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps.

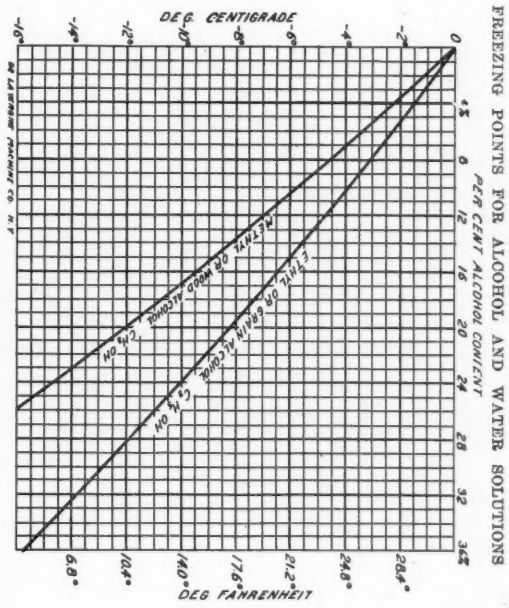
POWER PLANT ENGINEERING

CUBIC FEET OF AMMONIA VAPOR TO BE CIRCULATED PER MINUTE PER TON OF REFRIGERATION


CU.FT. OF AMMONIA VAPOR TO BE PUMPED AT 200 LB. ABS. HEAD PRESS. FOR 1 TON OF REFRIGERATION PER DAY
23.0 11.865 8.054 6.401 4.957 4.171 3.580 3.039 2.822 2.498 2.329 2.102 1.880
SUCTION PRESSURE LB. ABS.
5 10 15 20 25 30 35 40 45 50 55 60 65
CU.FT. OF AMMONIA VAPOR TO BE PUMPED PER TON OF REFRIGERATION
3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0
CORRECTION FACTOR
200 LB. ABS. HEAD PRESSURE
0.94 0.95 0.96 0.97 0.98 0.99 1.00 1.01 1.02 1.03
CORRECTION FOR VARYING CONDENSER PRESSURE
240 220 200 180 160 140
CONDENSER PRESSURE LB. ABS.

SANWALD IN REFRIGERATING WORLD

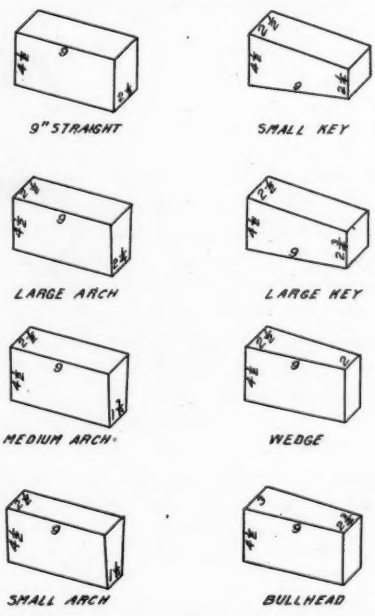
POWER PLANT ENGINEERING


DEG. CENTIGRADE
-9° -4° -1° 0° 4° 9° 15° 21° 27° 32°
PER CENT ALCOHOL CONTENT
0 4 8 12 16 20 24 28 32 36
ETHYL OR GRAIN ALCOHOL C_2H_6O
METHYL OR WOOD ALCOHOL CH_4O
6.8° 10.4° 14.0° 17.6° 21.2° 24.8° 28.4°
DEG FAHRENHEIT

FREEZING POINTS FOR ALCOHOL AND WATER SOLUTIONS

POWER PLANT ENGINEERING

STANDARD FIRE BRICK DIMENSIONS



POWER PLANT ENGINEERING

STANDARD FIRE BRICK DIMENSIONS

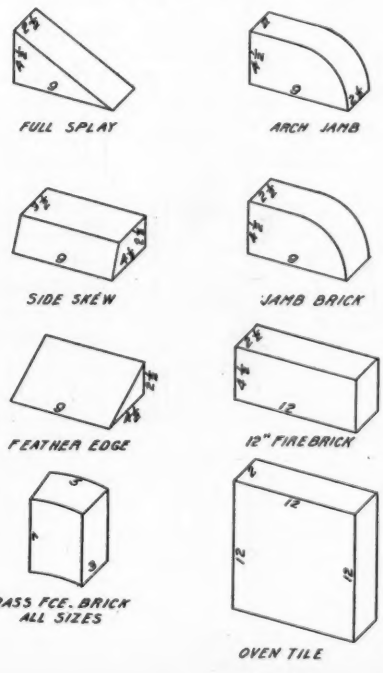
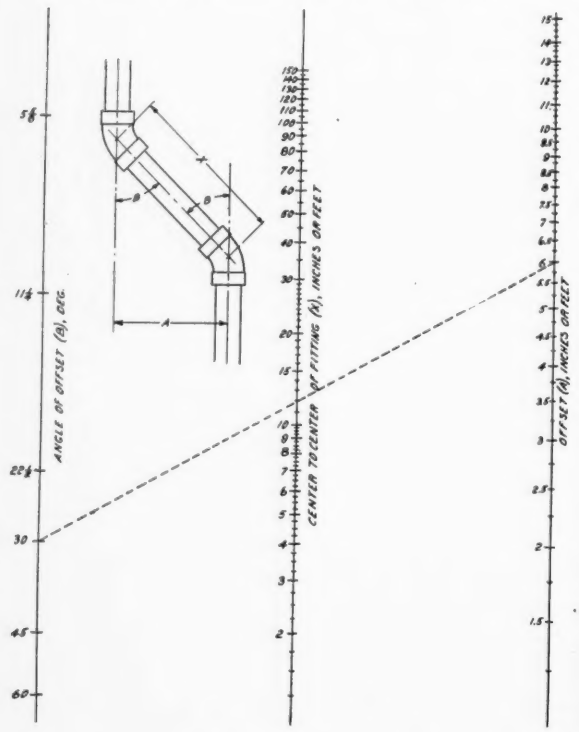
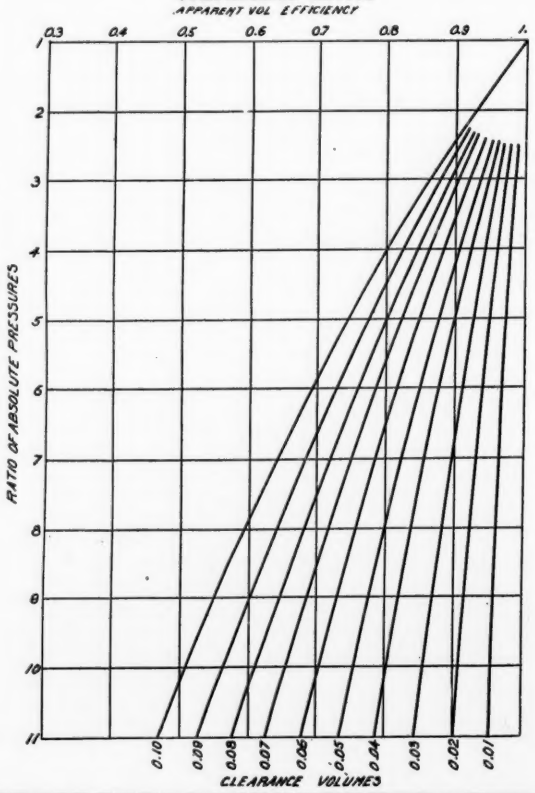


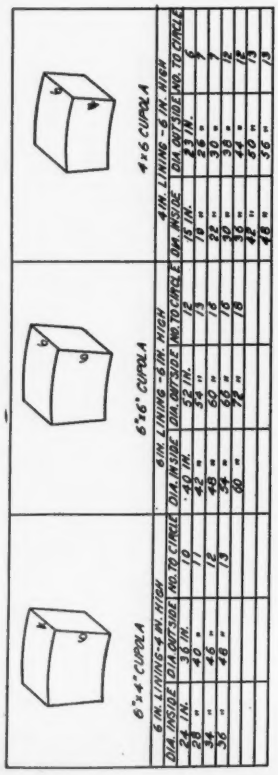
CHART FOR CALCULATING PIPE OFFSETS



APPARENT VOLUMETRIC EFFICIENCY OF AMMONIA COMPRESSORS WITH VARIOUS CLEARANCES AND COMPRESSION RATIOS



STANDARD FIRE BRICK DIMENSIONS



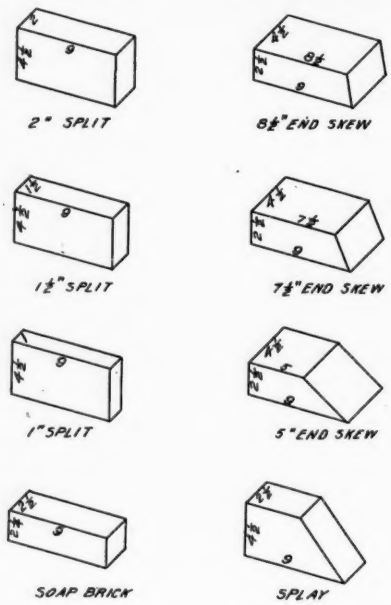
DIA. INSIDE	DIA. OUTSIDE	NO. TO CIRCLE
6 IN. LINING - 6 FT. HIGH		
24 IN.	40 IN.	19
30 "	46 "	15
36 "	48 "	15
6 IN. LINING - 6 FT. HIGH		
24 IN.	48 "	18
30 "	60 "	15
36 "	72 "	18
4 IN. LINING - 6 IN. HIGH		
16 IN.	32 IN.	13
18 "	36 "	15
20 "	40 "	15
24 "	48 "	18
30 "	60 "	15
36 "	72 "	18
4 IN. LINING - 6 IN. HIGH		
16 IN.	32 IN.	8
18 "	36 "	9
20 "	40 "	10
24 "	48 "	12
30 "	60 "	15
36 "	72 "	18

STOCK TILES AND BLOCKS

12	×	6	×	2	12	×	12	× 3
12	×	12	×	2	14	×	12	× 3
14	×	14	×	2	16	×	12	× 3
15	×	12	×	2	18	×	12	× 3
16	×	12	×	2	18	×	18	× 3
16	×	16	×	2	20	×	12	× 3
18	×	12	×	2	20	×	18	× 3
20	×	12	×	2	24	×	18	× 3
24	×	12	×	2	30	×	18	× 3
30	×	12	×	2	30	×	24	× 3
					30	×	30	× 3
					36	×	12	× 3

12	×	4	×	4				
12	×	12	×	4				
16	×	12	×	4				
18	×	12	×	4				
18	×	18	×	4				
20	×	12	×	4				
24	×	18	×	4				
30	×	12	×	4				
30	×	24	×	4				
30	×	30	×	4				
36	×	12	×	4				
24	×	8	×	4				

STANDARD FIRE BRICK DIMENSIONS



Flywheel Explosion Kills Attendant

ON Sept. 19, at the plant of the Chicago Coated Board Co., Chicago, Ill., a flywheel having a diameter of 14 ft. and width 36 in. exploded, resulting in the instant death of the oiler and considerable damage to building and machinery. The flywheel, which was keyed to the shaft of a 500-hp. Corliss engine running at a speed of 110 r.p.m., wrecked itself to such a degree that repairing is beyond consideration.

The wheel served both as flywheel and belt wheel and the rim was rather thin in comparison to its width, having a width of 36 in. and thickness 1⅝ in. with a 3-in. flange on each side extending inward. The approximate weight of the rim was 9000 lb. It was of the split type, bolted at the rim through flanges on the inner side of the rim which broke at these points. At the hub four bolts held the wheel together and all of these broke directly under the nuts.

The main belt was 30 in. wide and transmitted power to a line shaft in the beaver room through a pulley of smaller diameter than the flywheel.

PHOTOGRAPH SHOWING MANY PARTS INTO WHICH THE EXPLOSION CAUSED THE WHEEL TO BE SEPARATED

The six spokes with the exception of one were broken into two, three and four pieces. The hub was so completely broken that no two spokes remained together. The rim and outer flanges were also hurled into many parts and did considerable damage.

The eccentric and valve stem of another unit of the same capacity operating beside the wrecked engine was damaged by flying parts, which also caused damage to the flywheel of another engine direct connected to a 60-kw. generator in the same room, severing it in half.

The roof of the power house was completely demolished and a hot water tank, set on the roof slightly beyond the engine room, had its side dented and the manhole cover blown off. The steam pipes leading to these units were entirely demolished in the engine room, the conduits of the electrical system suffered likewise, rendering nearly three-fourths of the entire system useless.

The expert mechanical engineer of the firm so far has failed to ascertain the cause of the explosion. Several expert mechanical engineers were consulted and the parts examined by them, with no decision as to the cause of the explosion.

The first opinion was that for some cause the governor of the engine failed to regulate the cutoff, causing an excessive flow of steam, hence an increased speed; but this theory was thoroughly investigated and nothing found to substantiate it, because, had the engine speeded up as little as 2 r.p.m. the excess would have been immediately noticed in the plant.

The men operating machinery driven by this unit were questioned as to an increased speed, but no one had noticed any excess.

From the illustration, an approximate idea can be gotten as to the many parts into which the explosion caused the wheel to be separated.

The oiler, who was instantly killed, was the only person in the engine room at the time of the explosion and the only one who could possibly have known the cause of the accident. The firm is making a thorough investigation as to the exact cause of the explosion.

Electrical and Mechanical Engineer Wanted

WEST CHICAGO PARK COMMISSIONERS ARE CONTEMPLATING A COMBINATION OF THEIR PRESENT ELECTRICAL DIVISION AND STEAM HEATING DIVISION INTO A MECHANICAL AND ELECTRICAL DIVISION

IF the contemplated change is made, a Mechanical and Electrical Engineer will be placed at the head of the new division. This announcement is being made in order to get in touch with persons interested in this new position, which will pay about $3300 a year at the start and $3600 a year as soon as the incumbent has fully demonstrated his ability to handle the work satisfactorily. The Mechanical and Electrical Engineer will also be allowed the use of an automobile while on duty.

The entire service of the Park Commissioners is operating under a stringent civil service law which insures permanent tenure to all efficient and competent employes. The final appointment to this new position will be given to the person who receives the highest average in a civil service examination open to men residing anywhere in the United States.

The work of the Mechanical and Electrical Engineer will include responsibility for and supervision of the following:

The operation, maintenance and repair of the electric lighting system for over 30 mi. of boulevards, and 800 acres of parks, including high-tension transformer sub-stations and transmission lines, and all auxiliary apparatus; also the design, maintenance and repair of illuminating equipment in all park buildings. The preparation of plans and specifications for alterations and new electrical construction work and supervision of their execution will also be included.

The operation, maintenance and repair of about 14 low-pressure steam heating plants and five high-pressure steam plants, located in the various park and playground buildings throughout the system. The high-pressure plants vary in size from 100 to 1000 hp. These are operated for heating and ventilating park buildings and

furnishing steam for park laundries. Responsibility for the economy of operation of all these plants will be one of the important functions of the Mechanical and Electrical Engineer. He will also be responsible for the layout of alterations to present plants, and the construction of new heating and ventilating installations.

All persons interested in a position of this character are urged to communicate with A. C. Schrader, Supt. and Chief Engineer, West Chicago Park Commissioners, Union Park, Chicago, or with the undersigned. In writing, please state extent of education and past experience.

FRED. G. HEUCHLING,
Superintendent of Employment, Union Park, Chicago.

William Kent

IN THE death, on Sept. 18, of William Kent, the engineering profession has lost one of its most prominent and helpful members. Born in Philadelphia on March 5, 1851, Mr. Kent received his early education there, graduating from the Central High School in 1868. Later he entered Stevens Institute, from which he graduated in 1876. During the time he attended the institute and until 1879 he assisted Professor R. H. Thurston on the United States Board appointed to test iron, steel and other metals. Positions as mechanical engineer and superintendent in various large iron and steel works and boiler factories occupied his time in the next decade of his career. Mr. Kent's "Mechanical Engineer's Pocket Book" was first published in 1895, and is now in its ninth edition; through this work, Mr. Kent is probably most widely known. From 1895 to 1903 he was associate editor of Engineering News, he also held the position of editor of Industrial Engineering and was on the editorial staff of the American Manufacturing and Iron World. From 1903 to 1908 Mr. Kent was dean of the L. C. Smith College of Applied Science of Syracuse University, since which time he has been engaged principally in the practice of general consulting engineering.

Books and Catalogs

HANDBOOK ON PIPING, by Carl L. Svensen; 359 pages, 359 illustrations, 6 by 9 in.; New York, 1918. Cloth; price, $4.

Starting with the bored out log, this interesting book jumps quickly to modern piping of steel, iron, brass and lead, giving standard data as to dimensions, strength, fittings, joints and valves. It treats in detail of all these subjects.

The author then discusses the laying out of systems for steam, exhaust, water, heating, air, gas and oil, explaining the requirements of each and how to meet them, and giving examples of correct installation.

Chapters treat on erection, insulation, drawings and specifications, thus rounding out the subject and giving complete information for handling a job, from the first rough plan and sketches to the finished installation.

The author has drawn on practically every available source for information, and has produced a book that will be found invaluable for study and reference by every man who has to deal with piping in the power plant.

IN DETERMINING how most effectively to join any given belt, an engineer should consider the belt width, its thickness, the pulley diameter and the type of work. To make decisions in these matters so simple and easy that any unskilled workman may be intrusted with the work, the Crescent Belt Fastener Co. has prepared its new Crescent Service Chart, Form N. Y. 201, which gives in tabular arrangement all the data for every kind and make of belt of every length, width and thickness under all service conditions. This Service Chart should be of great assistance and value to engineers, purchasing agents and shop superintendents. Copies will be gladly mailed with full Crescent information to all interested parties.

IN ITS NEW CATALOG on Instruments and Relays, the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., announces two new duplex instruments for battery charging, marine, dental, telegraph, telephone, farm lighting and other compact instrument panels where direct-current is involved. These duplex instruments consist of any two standard Westinghouse type AW or type FW instruments desired, mounted in an attractive dull-black metal case. The type AW instruments have round open faces, 3 in. diameter, with glass cover and rear mounting studs; the type FW have 5-in. faces.

COCHRANE heaters, steam and oil separators and Multiport valves are described and illustrated in a recent circular of Harrison Safety Boiler Works, of Philadelphia.

THE LATEST NUMBER of Grinnell automatic sprinkler quarterly bulletin, a special hotel number, was recently published by General Fire Extinguisher Co., of Providence, R. I.

Trade Notes

A. J. BARNES has been appointed as export manager for the Shepard Electric Crane & Hoist Co., with headquarters at Montour Falls, N. Y. Mr. Barnes will also continue to act as Director of Publicity.

WALWORTH MFG. CO., of Boston, Mass., announces that at request of the War Industries Board it will discontinue the manufacture of the 6-in. Stillson wrench, the Walworth Stillson wrench with wood handle, in all sizes, and will use "war finish" as a standard on all wrenches for the duration of the war. No change has been made in patterns, material or workmanship, except that the finish will present a rougher appearance.

TWO BIG exhaust relief valves, weighing 12,300 lb. each, have just been shipped to the American Gas & Electric Co., at Peach Bottom, Va., by the G. M. Davis Regulator Co., Chicago. These are 42-in. valves, measuring 80 in. from face to face of the flanges. The bodies and discs are of cast iron, and the stems, seat rings and stuffing box glands are of bronze. The water drains are supplied with outside connections, ¾-in. inlet and 1-in. overflow. Heavy brackets cast on each side of the bodies provide means for support. This is a repeat order, as two similar Davis valves were previously supplied to the same company.